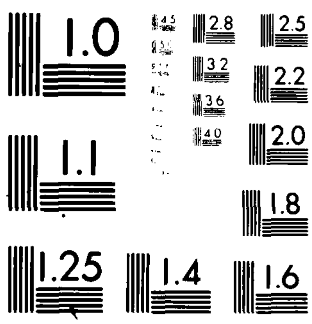
AD-A098 125   MANTECH INTERNATIONAL CORP ARLINGTON VA   F/G 15/3
TECHNOLOGY SURVEY OF ADVANCED ARMY WEAPON SYSTEMS AND THEIR SUP--ETC(U)
MAR 81   J J RESSA, M COHILL   N00024-79-C-7045

UNCLASSIFIED   CORADCOM-79-7045-F   NL

1 OF 2

9812



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU [illegible] STANDARDS [illegible]

LEVEL II ①

RESEARCH AND DEVELOPMENT TECHNICAL REPORT
CORADCOM–79–7045–F

AD A098125

TECHNOLOGY SURVEY OF ADVANCED ARMY WEAPON SYSTEMS AND THEIR SUPPORT REQUIREMENTS

MANTECH INTERNATIONAL CORPORATION
2341 Jefferson Davis Highway
Arlington, Va 22202

MARCH 1981

DISTRIBUTION STATEMENT

Approved for public release;
distribution unlimited.

PREPARED FOR:

CENTER FOR TACTICAL COMPUTER SYSTEMS

CORADCOM

US ARMY COMMUNICATION RESEARCH & DEVELOPMENT COMMAND
FORT MONMOUTH, NEW JERSEY 07703

81 4 23 032

NOTICES

Disclaimers

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 19 CORADCOM-79-7045-F	2. GOVT ACCESSION NO. AD-A098 425	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Technology Survey of Advanced Army Weapon Systems and Their Support Requirements		5. TYPE OF REPORT & PERIOD COVERED Final Oct 79-Sep 80
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John J. Ressa, M. Cohill		8. CONTRACT OR GRANT NUMBER(s) N00024-79-C-7045
9. PERFORMING ORGANIZATION NAME AND ADDRESS Mantech International, 2341 Jefferson Davis Hwy, Arlington, VA 22202		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS OMA FY 79 Project 738017
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Communication Research & Development Cmd, ATTN: DRDCO-TCS-M, Ft Mon, NJ 07703		12. REPORT DATE March 1981
		13. NUMBER OF PAGES 95
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 97		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Automatic Test Equipment	Electro-Optics	EQUATE (AN/USM-410)
Technology Survey	Microwave Devices	
Advanced Army Weapon Systems	VLSI/VHSIC	
Support Requirements	Lasers	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This survey was initiated in response to a compelling need to increase ATE support capability to meet the test requirements of increased complexity of new technology areas in modern Army weapon systems. Four weapon systems were surveyed to determine the major technological advancements: Advanced Attack Helicopter, XM-1 Main Battle Tank, TOW Heavy Antitank Missile and Fighting Combat Vehicle Systems. This technological survey resulted in recommendations to the Army to conduct research and development which will result in an increased (over)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified 394425

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

capability of ATE in the fields of Electro-Optics (Fiber Optics, Low-energy lasers, high-energy lasers and imaging devices), microwave devices and Very Large Scale Integrated Circuits/Very High Speed Integrated Circuits (VLSI/VHSIC).

TABLE OF CONTENTS

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (cont'd)

1.0 INTRODUCTION

1.1 Background

The Army is increasingly investing in Automatic Test Equipment (ATE). This investment has been prompted by the ability of ATE to:

- Accelerate testing
- Improve accuracy and consistency
- Consolidate testing requirements
- Shorten turnaround times
- Reduce the drain on spares and provide the flexibility needed to respond to rapidly changing support needs imposed by increasingly complex weapon systems.

The need for transition from manual test techniques to automatic test equipment is driven by a continued shortage of trained maintenance personnel and a decrease in the educational level of new personnel. Additional factors serving to mandate the need for ATE are a quantum leap in sophistication and complexity of the weapon systems that must be supported and the shortened life of these weapon systems due to new advances in technology and changes in missions to respond to changing threats and strategies.

This study was initiated in response to a compelling need to increase ATE support capability to meet the test requirements of increased complexity of new technology areas in modern Army weapon systems.

1.2 Study Objectives

In response to this need, ManTech began a study in October, 1979 of "Modern Army Weapon System Technology" under Contract Number N00024-79-C-7045 with the U.S. Army, Fort

Monmouth. An overall objective of the report was to identify state-of-the-art weapon system developments so that early identification of tester needs may be readily accomplished. This objective was to be achieved through an identification of modern Army weapon systems, a detailed investigation of the new technologies used in these weapon systems, evaluation of support requirements, and an investigation of non-military trends related to these new technology areas. The research was structured into four tasks, specifically to:

- Identify these weapons systems which will represent the new technologies present in the Army's scenario of modern weapon systems.
- Identify and examine the technologies utilized in the selected weapon systems.
- Initiate a survey to determine the support requirements of the weapon systems and the present support posture of each command. Recommendations should be made of where future tester developments should be focused.
- Investigate non-military trends in these new technology areas. An analysis should be made of how these technology developments will impact future military technology and support requirements.

1.3 Organization of the Report

This technical report on advanced Army weapon systems consists of the following:

- Section 1 contains the introduction to the report, with a background on advanced Army weapon systems and the need for ATE support, and a description of the objective and tasks of this study effort.
- Section 2 contains the executive summary which includes major Army technological advancements, present Army ATE capability, new support requirements and recommendations.
- Section 3 discusses the report approach and methodology, the literature search, data collection and analysis, new technology support requirements and trends of non-military technologies.
- Section 4 describes the advanced Army weapon systems new technology areas.
- Section 5 discusses new technology area support requirements.
- Section 6 presents trends of non-military technologies that could possibly impact future Army technology and support requirements.
- Appendix A presents a general description of the major advanced Army systems selected for this study.
- Appendix B is sample questionnaire for the Test Measurement and Diagnostic Support Technology Survey.

2.0 EXECUTIVE SUMMARY

2.1 Introduction

This section summarizes the following:

- Major Technological Advancements of Advanced Army Weapon Systems
- New Systems Support Requirements
- Present Army ATE Capability
- Recommendations

2.2 Major Technological Advancements

The major technological advancements found in the four surveyed weapon systems were:

(1) Advanced Attack Helicopter

- Fiber-Optic Cable used in weapon systems package
- Target Acquisition Designation Sight (TADS) which includes Direct View Optics (DVO), Forward Looking Infrared (FLIR) devices, TV, Laser Designator/ Rangefinder, and a Laser Tracker.
- Pilot Night Vision System (PNVS) which contains a Forward Look Infrared (FLIR) device for nap-of-earth flying capability.

(2) XM-1 Main Battle Tank

- Solid State Laser Rangefinder
- Thermal Imaging Sight (TIS)
- Image Intensifier Tube with Microchannel Array is used in the AN/VVS-2 night vision device
- Fiber Optic Cable Tapered is found in XM-1 version of the AN/VVS-2

(3) TOW (Tube Launched, Optically Tracked, Wire Guided) Heavy Antitank Missile

- Thermal Infrared Imaging Night Sight (AN/TAS-4)

(4) Fighting Combat Vehicle Systems (XM-2,3)

- Primary weapon sight uses thermal infrared technology utilizing common modules of the TOW AN/TAS-4 system.
- Image Intensifier Tube with Microchannel Array is used in the AN/VVS-2 night vision device

2.3 Present Army Capability

The U.S. Army's prime ATE system is RCA's EQUATE (AN/USM-410). Table 1 lists abbreviated technical specifications of EQUATE. The following additional support equipment is developed or is under development to supplement EQUATE:

(1) Developed:

- XM-1

  Direct Support - Thermal System Test Set (TSTS); Direct Support Electrical System Test Set (DSESTS)

- TOW

  AN/TAM-4 - Battle Charging/Cleaning Static

  AN/TAM-3 - Night Sight Test Facility

(2) Under Development:

- AAH

  Electro-optical augmentation to supplement EQUATE.

- XM-1 - Simplified Test Equipment (STE)
- XM-2 and XM-3

  Modifications planned for Simplified Test Equipment -XM-1, DSESTS-XM-1 and EQUATE.

MFR. NAME RCA
ATE NAME AN/USM-410

STIMULUS

DIGITAL	DYNAMIC	20V, 2MHz
	STATIC	
	LOGIC TYPE	
	I/O CHARS	
	SIMUL. I/O REQ.	128
PWR	DC	1000V
	AC	115V
ANALOG	SINE	6MHz
	SQUARE	3MHz
	TRIANGLE	3MHz
	SAWTOOTH	3MHz
	PULSE	10MHz
	ARBITRARY	3MHz
RF	CW	18GHz
	AM	50KHz
	SSB	
	SCM	
	FM	100KHz
	PULSE	10KHz
SPECIAL	SYNCHRO	11.8V@400Hz 0° to 360°
	RESOLVER	
	LASER	
	PRESSURE	
	OTHER	
LOAD	R	9 M ohms
	L	
	C	
	COMPLEX	

RESPONSE

DIGITAL	DYNAMIC	200V, 2MHz
	STATIC	
	LOGIC TYPE	
	I/O CHARS	
	SIMUL. I/O REQ.	120
VOLTAGE	DC	±200V
	AC	140RMS, 200peak
	RFV	
	RFP	-35dbm to +10dbm
	SAMPLED	
F/T	FREQ.	18GHz
	TIME INT.	20ns to 10 sec
ANAL	WAVAN	500MHz
	SPECAN	300MHz
	FFT	
RF DEMOD	AM	
	SSB	
	SCM	
	FM	
	PULSE	
SPECIAL	SYNCHRO	60Hz to 100KHz
	RESOLVER	
	LASER	
	PRESSURE	
	OTHER	
Z	R	1 M ohms
	L	
	C	
	COMPLEX	

TABLE 1 - EQUATE AN/USM-410 SPECIFICATIONS

2.4 New System Support Requirements

The selected advanced Army weapon systems new technologies found to be inadequately supported or found to require additional support equipment were identified in the questionnaire and additional data received. The two systems warranting major support development were the following electro-optical systems:

(1) Laser Rangefinder/Designator Systems

(2) Infrared Imaging Systems

Microwave Devices were not found on the selected systems. Very Large Scale Integrated Circuits/Very High Speed Integrated Circuits (VLSI/VHSIC) found on the AAH (Advanced Attack Helicopter) were adequately supported by EQUATE.

2.5 Recommendations

This technology survey of support requirements to meet increased testing complexity of new technology areas in modern Army weapon system recommends:

(1) Electro-Optics: Fiber-Optics

It is recommended that the Army study the testing requirements imposed by fiber-optic components in future weapon systems, and investigate the potential applicability of fiber-optic technology to Automatic Test Equipment (ATE). This effort should include the following tasks:

- Standardize fiber-optic components and test methods.

- Develop Automatic Test Equipment (EQUATE(AN/USM-410) and fiber-optic augmentation) in support of weapon systems that involve fiber-optics.
- Conduct research and development on built-in-test for fiber-optic systems.

(2) Electro-Optics: Low-Energy Lasers

It is recommended that the Army undertake R&D to improve low-energy laser testability,reliability, and repairability. This effort should include the following tasks:

- Investigate the feasibilty of using built-in-test to determine the operational readiness of a laser and/or to locate faulty components and improper alignment.
- Standardize maintenance procedures and the laser/test equipment interface.
- Sponsor development of modular design with built-in-test for low-power lasers.

(3) Electro-Optics: High-Energy Lasers

It is recommended that the Army establish a central authority that will survey high-energy laser development activities, and after determination of system designs the authority will define built-in-test, test equipment, and logistics support requirements.

(4) Electro-Optics: Imaging Devices

It is recommended that the Army recognize the significant changes taking place in imaging-device technology, and address the new maintenance requirements resulting therefrom. This effort should include the following tasks:

- Survey state-of-the-art trends in arrays and architecture with a view to standardizing input-output formats, both optical and electrical.
- Develop modularized component-replacement and component-alignment concepts for imaging devices.
- Define requirements for field-ruggedized secondary transfer standards, capable of characterizing replacement imaging devices.

(5) Microwave Devices

It is recommedned that the Army define requirements for and improve performance testing and fault isolation in radio-frequency/ microwave devices and circuits. This effort should include the following tasks:

- Survey future advanced Army weapon systems and identify microwave technology.
- Develop techniques for improved test access, contactless testing, and built-in-test in Radio Frequency (RF) and microwave devices and circuits.
- Generate a precise difinition of RF test accuracy requirements and appropriate test methods, and develop needed RF test instrumentation that could augment EQUATE If incapable of testing alone.

(6) <u>Very Large Scale Integrated Circuits/Very High Speed Integrated Circuits (VLSI/VHSIC)</u>

With initiation of the DoD development program on Very High Speed Integrated Circuits (VHSIC) and commercial trends toward the use of Very Large Scale Integration, it is recommended that the Army initiate research and development of automatic test equipment incorporating higher speeds (1 to 4 GHz clock rate) and throughput. It is also recommended that the Army investigate and utilize the potential of the microprocessor for implementing built-in-test and fault-tolerant design. This effort should include the following tasks:

- Develop built-in-test and fault-tolerant design concepts utilizing microprocessor technology.
- Generate test standards for microprocessor.

3.0 APPROACH

The report encompassed the following functions:

- Identification of new major Army weapon systems and their new technologies.
- The collection of data to form a base with which to draw conclusions relative to Army weapon systems support requirements.
- The analysis of data to identify the factors having impact on Army weapon system support requirements.
- Identification of new support requirements.
- The collection and analysis of data on trends on non-military technologies.

3.1 Identification of Army Weapon Systems

The advanced Army weapon systems identified for this study were selected from a group of candidate weapon systems (see Figure 1) scheduled for deployment in the next five to eight years. Under agreement with U.S. Army, Fort Monmouth, the weapon systems selected to determine their new technology impact on support requirements were the following:

- Advanced Attack Helicopter
- XM-1 Main Battle Tank
- Fighting Combat Vehicle Systems
- TOW (Tube Launched, Optically Tracked, Wire Guided) Heavy Antitank Missile
- High Energy Laser Systems

The U.S. Army High Energy Laser System Programs, as described in Appendix A, support requirements are presently unknown.

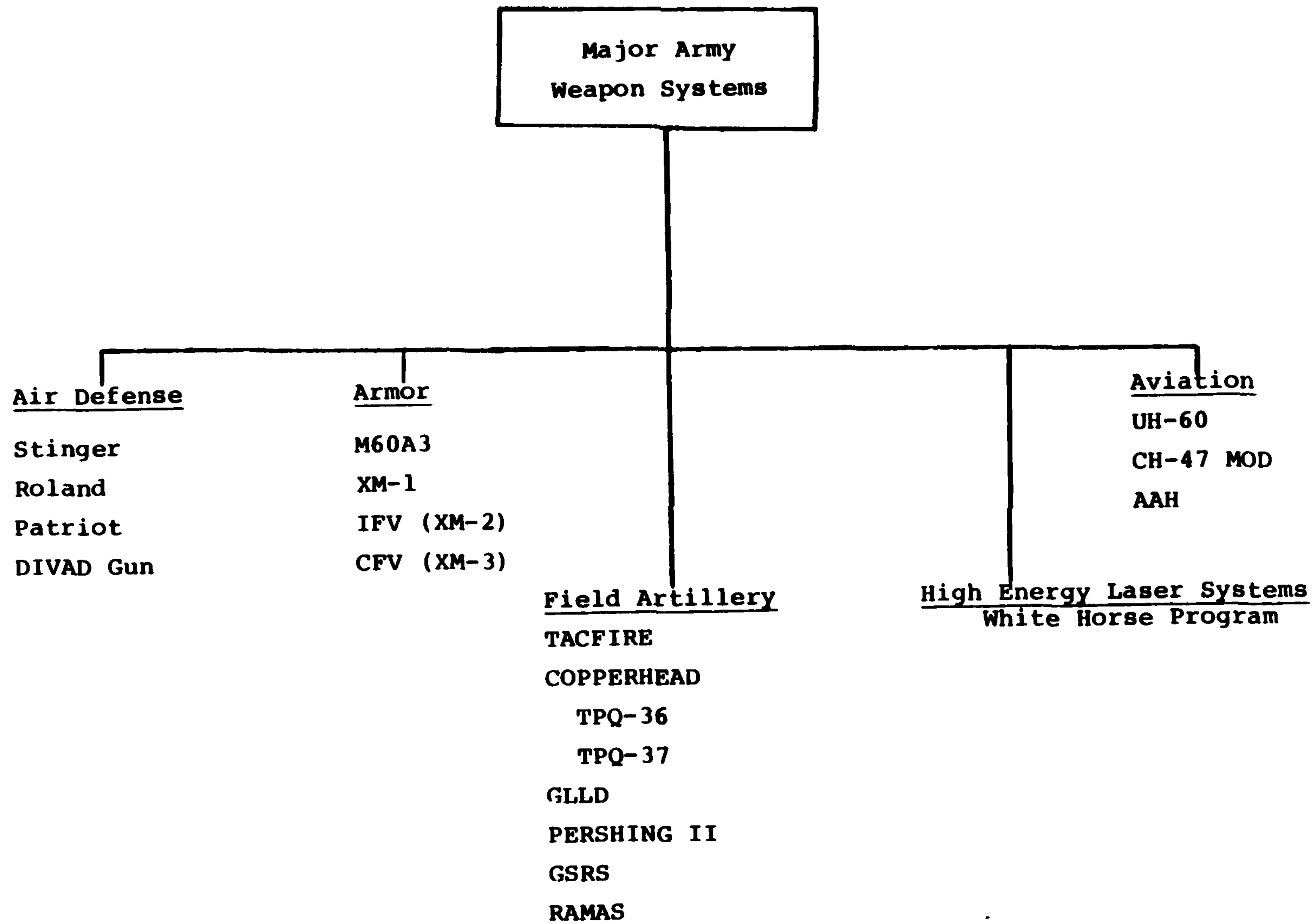


Figure 1 Candidate Army Weapon Systems

3.2 Identification of Weapon Systems New Technologies

The advanced Army weapon systems new technologies which were identified as having the greatest impact on the Army support posture were the following:

- Electro-optical systems
- Microwave Devices
- Very Large Scale Integrated Circuits/Very High Speed Integrated Circuits (VLSIC/VHSIC)

Electro-optics includes: (1) Fiber-Optics transmitters, receivers, cable and switches; (2) Laser types such as chemical, gas, solid state, dye, and also laser rangefinders, and designators; and (3) imaging and display devices and their components such as IR photodetectors, coolers, Charge-Coupled Devices (CCD), intensifier tubes, etc.

Microwave Devices encompass: (1) millimeter wave tubes (TWT), klystrons, magnetrons, etc.; (2) solid states devices such as bi-polar, Field Effect Transistor (FET), etc.; and (3) Surface Acoustic Waves (SAW) Josephson Junctions and Monolithic Integrated Circuits (ICs).

VLSI/VHSIC include the following:

- ICs for logic
- Memory
- Signal Processing
- Microprocessors
- Charge Coupled Devices (CCD)
- NMOS
- Magnetic Bubble
- Magnetic Block Walls
- Microfabrication/Processing Technology

- Radiation Hardening
- Computer Aided Design (CAD)

3.2.1 Data Collection

The data collection consisted of a questionnaire sent to cognizant Army commands in charge of the advanced weapon systems, and an extensive literature search of technical journals for relevant information related to new technologies found in advanced Army weapon systems.

The questionnaire was divided into the following four sections:

- General Information
- Electro-Optics
- Microwave Devices
- Very Large Scale Intergrated Circuit Applications and Architecture

The questionnaire was sent to the following technical points of contact:

Name	Title/Code	Project/Location
Mr. David Bohan *	Director/DELNV-AC	Night Vision Lab, Fort Belvoir, VA.
Mr. Bill Brabson *	Deputy Program Manager/DRCPM-AAH	AAH Project/ St. Louis, MO.
LTC Clark Neal *	Project Manager/ DRCPM-FVS	Fighting Combat Vehicle Systems/Warren,MI.
LTC Joseph Jascewsky *	Project Manager/ DRCPM-GCM-ST	XM-1 Main Battle Tank/ Warren, MI.
Mr. J. Paul	Code DELNV-L	Night Vision and Electro-Optic Lab/Fort Belvoir, VA.
MG Longcore	Code DRCPM-DTY	TOW Dragon Missiles/ U.S. Army Missile Command, Redstone, AL.

* Questionnaire returned
Additional questionnaires sent to:

U.S. Army Missile Command, Information Center, Redstone, AL.

ATTN: DRSMI

Command General, U.S. Army Armament, Research and Development Command, Dover, N.J. ATTN: DRDAR-SC
A sample questionnaire is included in Appendix B.

The literature search included researching the following journals:

- Armor
- Army
- National Defense
- Jane's Weapon Systems 1979-1980
- Optical Spectra
- Electronic News
- Electronic Design
- 1980 Laser Focus Buyer's Guide
- The Optical Industry and System Directory 1978
- IEEE Spectrum
- Microwaves
- Microwave Systems News
- Aviation Week and Space Technology

Additional information was obtained from the following sources:

- Hughes Aircraft Company (Laser Rangefinder/Designator, and Infrared Imaging Systems)
- RCA Government System Division, (Papers entitled "Laser Testing at the Intermediate Maintenance Level" by Stokum and White, and "Automatic Testing of Electro-Optical Systems" by Berens and Welter).

3.2.2 Data Analysis

The data (questionnaire and literature search) for each system was carefully grouped and analyzed to identify new technologies. Support requirements for the new technologies were tabulated.

3.3 New Technology Support Requirements

The approach for determining new technology support requirements centers around present direct support (DS) and general support (GS) capabilities of the U.S. Army. The U.S. Army has selected as their prime ATE System RCA's EQUATE (AN/USM-410). Additional support equipment has been developed or is under development to supplement deficiencies in EQUATE. Therefore, the capabilities of EQUATE and the additional support equipment will be reviewed to determine if support requirements of the new technologies can be satisfied.

3.4 Trends of Non-Military Technologies

A review of the data received was conducted to determine if commercial or industrial activities were developing new technologies that have significant impact on the advanced Army weapon systems and their support requirements. Section 6 of this report discusses trends of non-military technologies that relate directly with technology in the advanced Army weapon systems.

4.0 NEW TECHNOLOGY AREAS

4.1 Electro-Optics

Electro-Optics is defined as the study of the behavior of physical and optical properties of electron beams under the influence of electric and magnetic fields in a vacuum. This also includes, in particular, the deflection and focusing of electron beams by such fields. An electro-optical system can best be described as shown in Figure 2. An object is viewed by optics and is transmitted using a fiber-optic transmitter. Electrical pulses are converted to light pulses via Light Emitting Diodes (LEDs) or Injection Laser Diodes (ILDs) which provide the light energy source that will flow through the fiber cable to a receiver. The receiver consists of a detector such as a PIN diode or other photo diode which converts the pulsed light back into electrical pulses that can be processed into an image by a display device such as a Cathode Ray Tube (CRT)

4.1.1 Fiber-Optics

Fiber-Optics is the process whereby light is transmitted through a long flexible fiber of transparent material, such as glass or plastic, by a series of internal reflections. Bundles of these fibers can transmit an entire image whereas each single fiber transmits but one component of the whole image. Therefore, the image may be magnified (by an increase toward the emergent end of the bundle), distorted (by random crossing of fibers), or curve shaped (by forming the bundle ends into convex, concave or shaped surfaces). Fibers can be made with a diameter of only a few microns, and many individ-

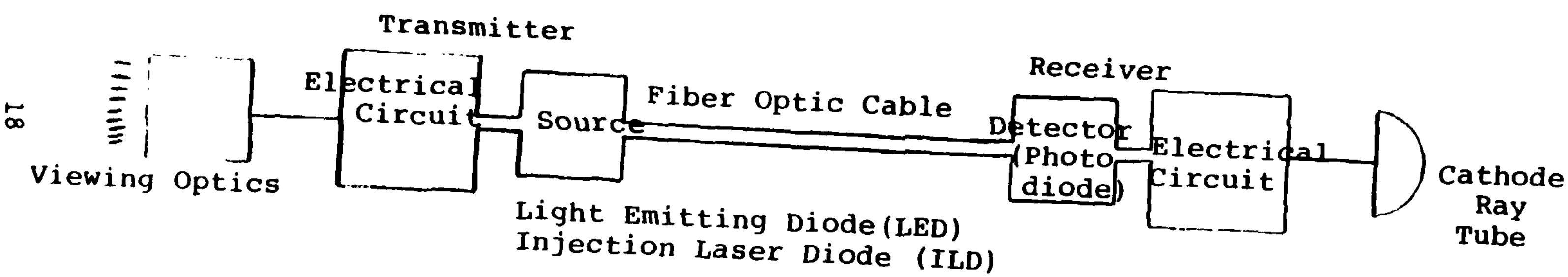


Figure 2 Sample Electro-Optical System

ual fibers can be fused together to form a rigid or flexible bundle. If the fibers are carefully arranged they can be used for image transfer, as in fiberscopes and image-tube faceplates or field flatteners in electro-optical devices.

Due to wieght limitations imposed on the Advanced Attack Helicopter (AAH), fiber-optic cable was utilized in their weapon systems package.

On the XM-1 main battle tank, the driver night vision sight, AN/VV S-2, contained a fiber-optic cable that is tapered (decreased in width) causing a reduction in image size.

4.1.2 Lasers

Laser is an acronym for light amplification by stimulated emission of radiation. A laser device generates or amplifies electromagnetic oscillations at wave lengths between the far infrared (submillimeter) and ultraviolet. A laser oscillator consists of two basic elements: an amplifying (active) medium and a regeneration or feedback device (resonant cavity). A laser's amplifying medium can be a gas, semiconductor, dye solution, etc: feedback is typically from two mirrors. The main characteristics of laser light are that it is usually more intense, more monochromatic, and more highly collimated than light from other sources.

The process of exciting the laser material (raising electrons to excited states) is referred to as pumping. Pumping can be done optically using a lamp, by an electrical discharge, a chemical reaction, or in the case of a semiconductor laser, by injecting electrons into an upper energy level by means of an electric current.

The typical output of an optical laser consists of a series of spikes occurring during the major portion of the time the laser is pumped. These spikes result because the inverted population is being alternately built up and depleted. Q switching (Q spoiling) is a means of obtaining all the energy in a single spike of very high peak power. This high peak power pulse is useful in optical ranging and communication and in producing non-linear effects in materials.

Low energy lasers which comprise the bulk of the so-far fielded lasers for military applications involve solid state, liquid, gaseous, and hybrid materials. High energy lasers deal with huge arrays of solid state or gas lasers (fusion) or with chemical/gas dynamic lasers for weapons applications and space warfare. The dividing point between low and high energy lasers is considered 1000 joules per pulse or power levels of 10 kilowatts of average power (continuous or pulsed).

4.1.2.1 <u>Solid State Lasers</u>

A solid state laser (optically pumped) is the type whose active medium is an atomic species in a glass or crystal. The atomic species may be added to the glass or crystal, as neodymium is added to glass, or may be intrinsic, as chromium is in ruby. Solid state laser range finders are in the military inventory as stand-alone devices or as part of integrated fire control systems. Solid-state lasers utilized on the advanced Army weapon systems outlined in Appendix A include:

- <u>Advanced Attack Helicopter</u>

  Included within the Target Acquisition Designation Sight (TADS) is a solid state laser rangefinder/designator to guide the Hellfire missiles.

  The rangefinder is a single pulse device. The transmitter is generally a Q-switched laser. The receiver is a photo-detective device. The output of the detector is fed into a time-measuring circuit which measures the elapsed time from emission to return.

  The laser designator is used to illuminate a selected target. The transmitter side of the rangefinder can be converted to a designator by modifying the firing circuitry to deliver a continuous stream of pulses.

  The solid state lasers in the laser rangefinder and designator systems use a crystal of Ytrium-Aluminum-Garnet (YAG) doped with a proper concentration of neodymium (Nd) ions that radiates at approximately 1.06 μm in the near infrared.

- XM-1

The XM-1 main battle tank fire control system utilizes a solid state laser rangefinder to determine target distance for their 105mm cannon. The solid state laser rangefinder also uses a crystal made of YAG doped with Nd.

4.1.2.2 Dye Lasers

A dye laser is a liquid laser that employs a liquid as the laser medium in place of a large single crystal or a gas. Dye laser's active medium is an organic dye, generally in solution, with the liquid either flowing, or encapsulated within a cell. The dye laser uses highly fluorescent organic molecules as the laser medium.

Dye laser technology is used in the XM-1 main battle tank fire control and surveillance system.

4.1.2.3 Gas Lasers

A gas laser is the type whose laser medium may be a very pure, single-component gas or mixture of gases. The laser medium may be a permanent gas or a vaporized solid or liquid. The active species in a gas laser may be a neutral atom, an ionized atom, or a molecule. Most gas lasers are excited by electric discharges (glow, arc, pulsed, RF, DC). Electrons which have been accelerated by an electric field transfer energy to the gas atoms and molecules by collisions. Gas lasers are utilized in the following advanced Army weapon systems:

- <u>Advanced Attack Helicopter (AAH)</u>

  Included within the Target Acquisition Designation Sight (TADS) and the Pilot's Night Vision System (PNVS) are Forward-Looking Infrared (FLIR) devices. CO_2 gas lasers are used as cueing devices in FLIR system which provide improved surveillance systems in smoke and fog operations. In principle, FLIRs produce a thermal image of the scene and from a military point of view, provide a display of potential targets embedded in the background. A FLIR-synchronized laser scan of the same scene will overlay the reflective/glint features with the thermal imagery and improve overall systems performance. The FLIR laser scan may also provide target velocity discrimination (laser radar).

  In addition, the PNVS FLIR sensor permits the AAH to be flown Nap-Of-the-Earth (NOE) in darkness and adverse weather conditions.

4.1.3 Imaging and Display Devices

An imaging display device converts an image in one spectral region directly into an image in another spectral band, usually with an increase in intensity. If the primary purpose is to convert the spectral region of the image (e.g., near infrared or ultraviolet to visible), the image device is called an image converter. If the primary purpose is to intensify the image without regard to spectral conversion, it is called an image intensifier tube. A tube designed to do both is categorized an image intensifier tube.

Direct-view image tubes utilize a photo-emissive input surface biased by a high voltage ranging from 4 to 20KV to accelerate and focus the image, and a phosphor screen to display the image, all contained in a single vacuum envelope. A solid state image converter has no vacuum envelope. The images formed by these devices are two-dimensional and are converted or amplified at all points simultaneously rather than being scanned as in a television system.

In an infrared imaging system, the image formed by the IR optics is swept across an array made up of a large number of cryogenically cooled photo detectors appropriately conditioned to form a composite video similar to television. When applied to a CRT, the resultant display is comparable to standard television. IR detectors are divided into two categories: quantum detectors and thermal detectors.

4.1.3.1 IR Photoconductors

An IR photoconductive detector (quantum detector) is a semiconductor in which the fluctuations in incident photons cause fluctuations inthe number of free charge-carriers, thus causing a change in conductivity. IR photoconductors are found in the following Army weapon systems:

- Advanced Attack Helicoptor (AAH)

  An IR photoconductive detector drives an LED array imaged on an Electro-Optic Multiplexor (VIDICON) which drives a CRT output. A VIDICON is a visual input device which contains a photoconductive surface that displays a direct readout from the photosensitive

target. The IR detector provides the input for the Forward-Looking Infrared (FLIR) image in the Target Acquisition Designation Sight (TADS) and the Pilot Night Vision System (PNVS).

- <u>TOW (Tube Launched, Optically Tracked, Wire Guided) Heavy Antitank Missile</u>

  Infrared photoconductors are used in Tow's infrared imaging night sight. The thermal infrared imaging night sight (AN/TAS-4), developed by Texas Instruments, allows full use of the system in darkness, as well as some capability in smoke, haze or against camouflage.

- <u>Fighting Combat Vehicle System</u>

  The primary weapon sight, which contains IR photoconductors, uses thermal infrared technology for the night portion of the system utilizing common modules of the TOW heavy antitank missile system.

4.1.3.2 <u>IR Photovoltaics</u>

An IR photovoltaic detector (quantum detector) is a pn semiconductor junction. Fluctuations in incident photon flux cause variations in the voltage produced by this junction. IR photovoltaics are used in conjunction with IR photoconductors in the AAH TADS and PNVS weapon systems.

4.1.3.3 <u>IR Thermal Detectors</u>

Infrared thermal detectors are of two types: (a) the <u>bolometric</u> detector reacts to changes in temperature by a change in its electrical conductivity; (b) the <u>thermovoltaic</u> detector is

a junction of two dissimilar metals (a thermocouple).

The XM-1 main battle tank's Thermal Imaging System (TIS) uses a bolometric IR thermal detector to sense small differences in infrared heat radiated by objects and converts the detected energy into electrical signals displayed on a CRT. The XM-1 thermal detector wavelength is 8-12 microns.

4.1.3.4 Coolers

It is usually necessary to cool infrared detectors to cryogenic temperatures to reduce the thermal noise inherent in an electrical transducer. Coolers are supplied for infrared detectors found on the following Army weapon systems:

- AAH, IR photoconductive and photovoltaic detectors.
- XM-1, IR bolometric thermal detector.
- TOW, IR photoconductive detectors.
- Fighting Vehicle Systems, IR photoconductive detectors.

4.1.3.5 Image Intensifier Tubes and Microchannel Arrays

An image intensifier tube is an electrostatic-focus tube. Most utilize modular construction and have fiber-optic faceplates on input and/or output ends. The electron lenses in the electrostatic-focus types invert the image, and both the object plane and image plane of electrostatic-focus electron optics are curved.

An electrostatic-focus microchannel intensifier utilizes electrostatic input focusing and proximity output focusing. This tube utilizes a microchannel array as an amplifier. It is used in military night sights because of its compact size, high resol-

ution, and high gain.

Image intensifier tubes and microchannel arrays are found on the Army weapon systems; XM-1, Fighting Combat Vehicles (FCV and IFV; XM-2,3).

The XM-1 main battle tank and the Fighting Combat Vehicles (XM-2,3) utilize the AN/VVS-2 Night Drivers Viewer. The AN/VVS-2 is a passive night vision device for drivers of armored fighting vehicles. The AN/VVS-2 uses image-intensifier equipment that is totally passive and requires no illumination. The 25mm micro channel image intensifier has automatic gain control and bright source protection. Technical characteristics are as follows:

Field of view:	45° x 38°
Total Field coverage:	135° horizontal x 38° vertical
Depth of focus:	4m to infinity
System resolution:	1.2 mils
System magnification:	Unity
Linear distortion:	Less than 4 percent
Image brightness:	Variable
Objective lens:	1/1.09, 33.5mm focal length
Image intensifier:	25mm with automatic gain control and bright source protection
Image tube gain:	25,000min
Bi-ocular magnifier:	45°, fixed focus

The XM-1 tanks modified AN/VVS-2 contains a fiber-optic tapered cable.

4.2 Microwave Devices

The advanced Army weapon systems evaluated in this technology survey contained no microwave devices.

4.3 VLSI/VHSIC (Very Large Scale Integration/Very High Speed Integrated Circuits)

VLSI/VHSIC technology was utilized only on the Advanced Attack Helicopter (AAH) weapon system. Microprocessors and memory chips were used in the electronics for system control, stabilization and pointing parameter signal processing, and self diagnostics.

5.0 NEW TECHNOLOGY SUPPORT REQUIREMENTS

5.1 Electro-Optics

A typical electro-optical system consists of an electronics package, optics, and an interface which is usually a device for converting electrical power to an optical output or vice versa. The support requirements (maintenance) of electro-optical systems can be divided into four areas: fault detection, fault isolation, repair, and check-out after repair to ensure the system is totally functional. Both the number and sophistication of electro-optical systems used by the Army have increased rapidly in the last few years. It has become desirable to maintain all these systems in a field environment to avoid the time and inconvenience of returning them to the manufacturer for maintenance, calibration, alignment, and repair. Automatic Test Equipment (ATE), used to maintain electro-optical systems, will reduce the number of maintenance personnel required, will allow them to be trained on a functional rather than system level, and will lower their required skill level.

The U.S. Army has selected as their prime ATE system RCA's EQUATE (AN/USM-410). To support the new technology in the advanced Army weapon systems surveyed, additional support equipment has been developed and electro-optical augumentation for AN/USM-410 is also under development.

The two major new technology electro-optical systems associated with the various candidate systems are the Laser Rangefinder/Designator and the Infrared Imaging Systems. Other electro-optical equipment such as Infrared (IR) point trackers, which are also present, represent no advanced technology, and the Test Measurement and Diagnostic Equipment (TMDE) for these equipments is well defined.

5.1.1 Laser Rangefinder/Designator (LRF/D)

A laser rangefinder/designator (LRF/D) is found on the Advanced Attack Helicopter (AAH). A laser rangefinder is also found on the XM-1 main battle tank. The laser systems in AAH and XM-1 tank are Q-switched in which a lasing rod is pumped with a flashtube and fired by increasing the Q of the lasing rod by some mechanical means. Both systems are produced by Hughes Aircraft Company.

Currently, the only depot capability for laser optics is at Sacramento Army Depot and consists of a test station and some special optical test equipment which was an adaptation of Hughes Manufacturing test equipment.

Typically, a rangefinder consists of:

a. One or more control/display units.

b. The actual laser unit which may have the electronics integral to the unit.

c. An electronics unit.

d. A set of cables and an electrical junction box or two.

The control/display units are basically switches and wires. At least one will have LED display and driving electronics on either a circuit board or some other type of removable electronic assembly.

The actual laser assembly has very little electronic/ electrical circuity. There is the high voltage wiring for the flash tube and the Q switch and its power and control. Typically, the Q switch is a motor driven mirror. The motor has very special high torque, low inertia characteristics which must be tested. The actual flash tube can be tested only in conjunction with the

laser firing. This requires a sophisticated radiometer and brings up the problem of laser safety.

The electronics associated with the laser transmitter include some basic timing circuits, a low voltage power supply, and a high voltage power supply. The timing circuits are digital with power output stages to drive the Q switch and the triggers. There are no specific test problems associated with these circuits as the testing is typical of digital logic test requirements. The low voltage power supplies also supply low voltage to the receiver circuitry. The high voltage power supply and high voltage pulse circuits are used to fire the flash tube. It delivers upon command a narrow pulse at +18kV.

The laser receiver consists of a photo-detector, an RF amplifier, a high speed digital time interval measuring system, a digital register, and output buffers. In addition, there is an analog timing circuit which generates a blanking signal for the detector. This blanking signal, called the Time Programmed Gain (TPG), biases the receiver front-end-off for a short period after lasing to prevent circuit saturation by close-in targets and scattered reflection.

The RF amplifier, a very broad band video amplifier, is very critical in terms of band pass and recovery characteristics. The test problems arise in the following:

- Taking care of transmission line problems in the test wiring.
- Generating very narrow pulses (<10 nano-sec).
- Measuring very narrow pulses.

The digital time interval circuits have a similar problem in that they must measure the time between two very narrowly spaced pulses. This applies throughout the circuits in that each of the digital range values is stored in a separate register and the shift between registers must be accomplished between pulses.

The TPG signal is basically a pulse with a very fast rise time and relatively high speed decay. The RF amplifier's test problems are an order of magnitude more critical than those associated with the TPG signal.

The support and test requirements include transmitter tests, receiver tests, and system level tests.

5.1.1.1 Test Requirements and Related Considerations

5.1.1.1.1 Transmitter Test

There are two major considerations in the testing of Laser Rangefinder/Designator transmitters. They are:

- Personnel safety
- Equipment performance requirements.

All laser transmitters are dangerous in terms of potential damage to the human eye. The potential is not hypothetical; the power densities used cause physical damage in glass optical components and readily form holes in sheets of paper. The implication of this fact is that the laser beam must be isolated from all personnel during tests requiring actual firing of the laser.

The performance characteristics can be verified by measuring:

- Peak power

- Beam quality
- Pulse width
- Sustained pulse peak power.

Of these four elements, only beam quality is uniquely dependent on the laser optics. The quality of the other elements is a function of both the optics and driving electronics.

Adequate radiometers are available for accomplishing the peak power measurement in the laboratory. These instruments are only marginally applicable in more stringent environments. These radiometers provide video outputs which may be examined with an oscilloscope to determine pulse width and pulse-to-pulse stability in designators. Automation of these measurements is difficult due to band pass requirements, the non-repetitive nature of the rangefinder pulses, and inherent jitter in pulse to pulse timing in designators.

Beam quality is defined in terms of dispersion and intensity distribution. Dispersion is specified in terms of angular beam width and is a measure of the degree of collimation achieved.

Dispersion is specified at the half power points and is some fraction of a milliradian. A conceptually simple method of measuring dispersion is to measure total beam power, then reduce the measurement aperture to reject energy outside of this dispersion limit and repeat the energy measurement. If the ratio of the first measurement to the second is less than two, the laser meets the requirement. In actuality this measurement is more complicated, but the technique is completely practical.

The laser emits more than one beam in most circumstances. The dispersion test will pass if a primary beam or a number of beams within the specified angle contain more than half the total beam power. A situation could exist where a second beam or group of beams outside of the specified angle might have power comparable to the primary beam. Such a dual beam situation is improbable. However, a secondary beam which is two orders of magnitude below the primary is probable. Such situations may develop with time as well as during manufacture or rework. A common method of testing for beam intensity distribution is to lase at a target, such as a sheet of polaroid film, and examine the resulting pattern visually. Recently a more sophisticated and less subjective technique has been developed: the laser illuminates a photodetector array; the output of the array is scanned by a microprocessor controlled sampler and the data is analysized by the micro-processor. It should be noted that all the tests discussed above except pulse width analysis can be performed by this system when properly calibrated. The detector array band pass is not broad enough to handle the pulse width analysis.

5.1.1.1.2 <u>Receiver Test (LRF only)</u>

Ideally the receiver optical section including the detector should be tested utilizing an optical source which closely resembles a laser reflection from a target. Practically, the laser is very difficult to simulate. In manufacturing of receivers, the light source used is generally a steady-state calibrated illuminator. Subsequent testing of the complete rangefinder unit is employed to verify LRF performance.

5.1.1.1.3 Laser Rangefinder System Level Test

The major test performed at this level is a performance test defining the ability of the LRF to range on remote multiple targets. The common name applied to this test is "extinction test". This test is performed on a range where a target board consisting of several well-defined surfaces is erected in a configuration allowing all targets to be illuminated by a pulse. The targets are separated in range by the minimum distance specified as range resolution.

The test is conducted in two steps - first, ranging is accomplished to establish that each target is detected and that the range numbers correspond to the distances to the target. The next step is to insert neutral density filters (optical attenuators) in the receiver path. At some attenuation level, the LRF will cease to respond to the target. This attenuation is defined as the extinction level and defines the overall LRF sensitivity.

Some problems associated with ranges and extinction tests are:

- Variation in test results - The test results are directly affected by the condition of the target surface. Any appreciable contamination of the surface affects its reflectivity and consequently changes the extinction ratio. The atmospheric conditions between the LRF and the target enter directly into the transmission characteristics of the range.
- Safety - The safety problems associated with the range are severe. While the protection of the test personnel can be achieved with protective goggles,

protection of casual personnel requires security levels in excess of those associated with small firing ranges.

- Real Estate - The range, if built at ground level, occupies an area of 500 meters long and as much as 200 meters wide. In addition, provision should be made to protect an extensive area extending up to several kilometers beyond the target.

5.1.1.1.4 Laser Rangefinder Potential Solutions to Test Problems

The safety, poor repeatability, and costs associated with the range testing, plus a requirement to check boresight and dispersion have initiated a large number of research and development projects. The Simulated Optical Range Test (SORT) developed by Hughes Aircraft Company is typical of one such project. This device is installed over the laser optical window(s). The laser optics are coupled to a fiber optic delay line which simulates the desired ranges. Several special optical coupler designs provide tests of boresight and dispersion. The basic attenuation of the devices is inherent in its optics and remains stable over its life. One version of the device is one cm thick by 10cm square.

5.1.2 IR Imaging System

Infrared (IR) Imaging Systems are found on the Advanced Attack Helicopter (AAH), XM-1, TOW, and Fighting Combat Vehicles (CFV & IFV) Army weapon systems.

The AAH IR Imaging System features an IR detector that drives a light-emitting diode (LED) array imaged on an electro-optical multiplexer (VIDICON) that drives a CRT output providing a real time FLIR image.

The XM-1 main battle tank's Thermal Imaging Sight (TIS) produces an image by sensing the small differences in infrared heat radiated by objects within view and converting the detected energy into electrical signals which can be displayed on a CRT. The XM-1 also uses image - intensifier equipment in their AN/VVS-2 Night Vision Drivers Viewer.

TOW's AN/TAS-4 thermal imaging night sight allows full use of the system in darkness and adverse weather conditions.

The CFV and IFV use thermal infrared technology for the night portion of their primary weapon sight utilizing common modules of the TOW heavy antitank missile system.

5.1.2.1 IR Imaging System Hardware

Figures 3 and 4 display common modules of an IR Imaging System and a Modular Forward-Looking Infrared (FLIR) System.

5.1.2.2 IR Imaging System Testing of Optics and Detectors

The testing of optics and detector in an infrared (thermal) imaging system is basically a problem of testing the detector array. A test is performed with the optics illuminated by an IR source which presents a uniform temperature large area with narrow strips or bars operating at higher temperatures. The source is commonly called a Bar Target. Each detector is scanned across the target and its response to the temperature differential is recorded.

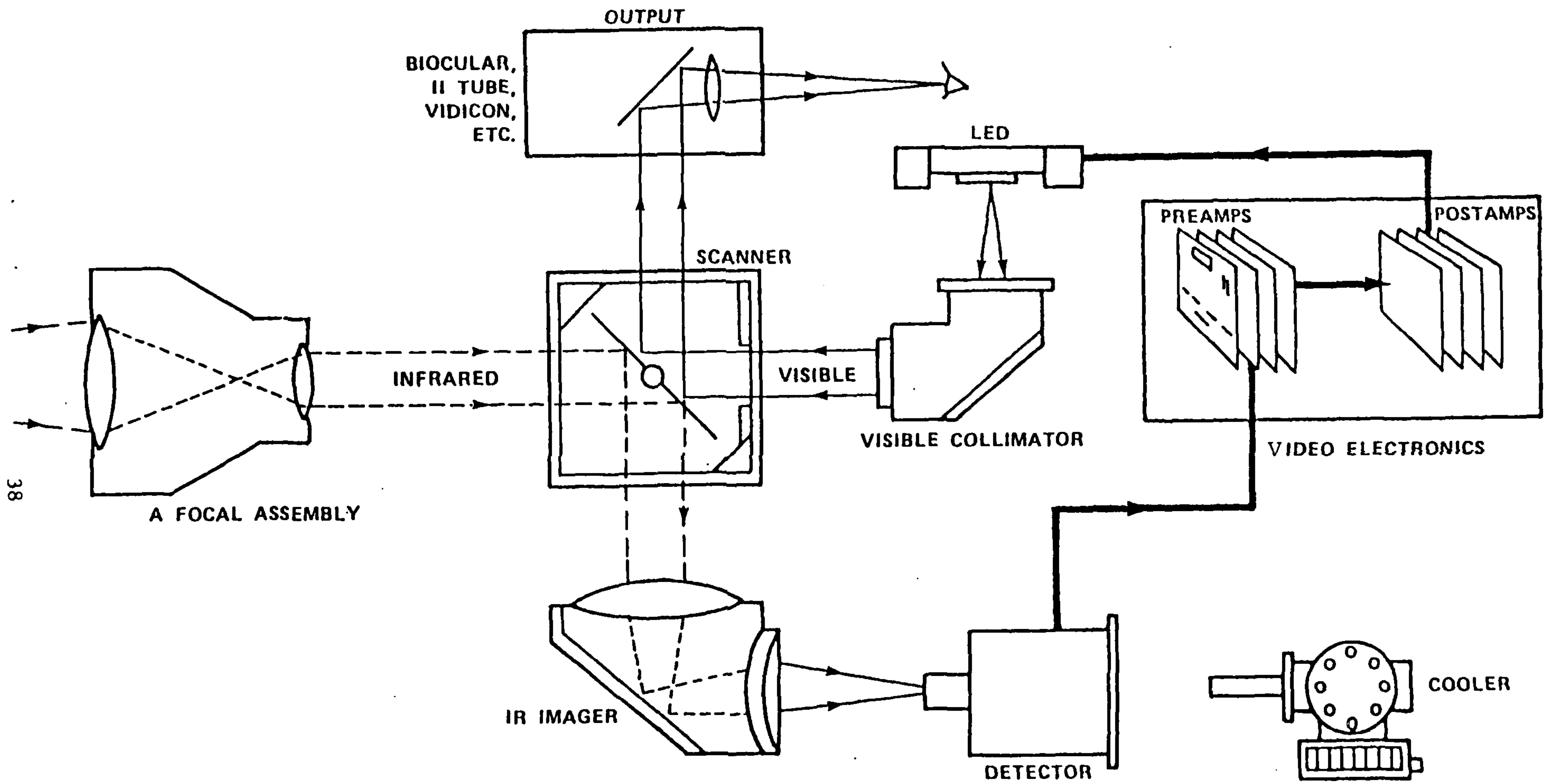


Figure 3 IR Imaging System Common Modules

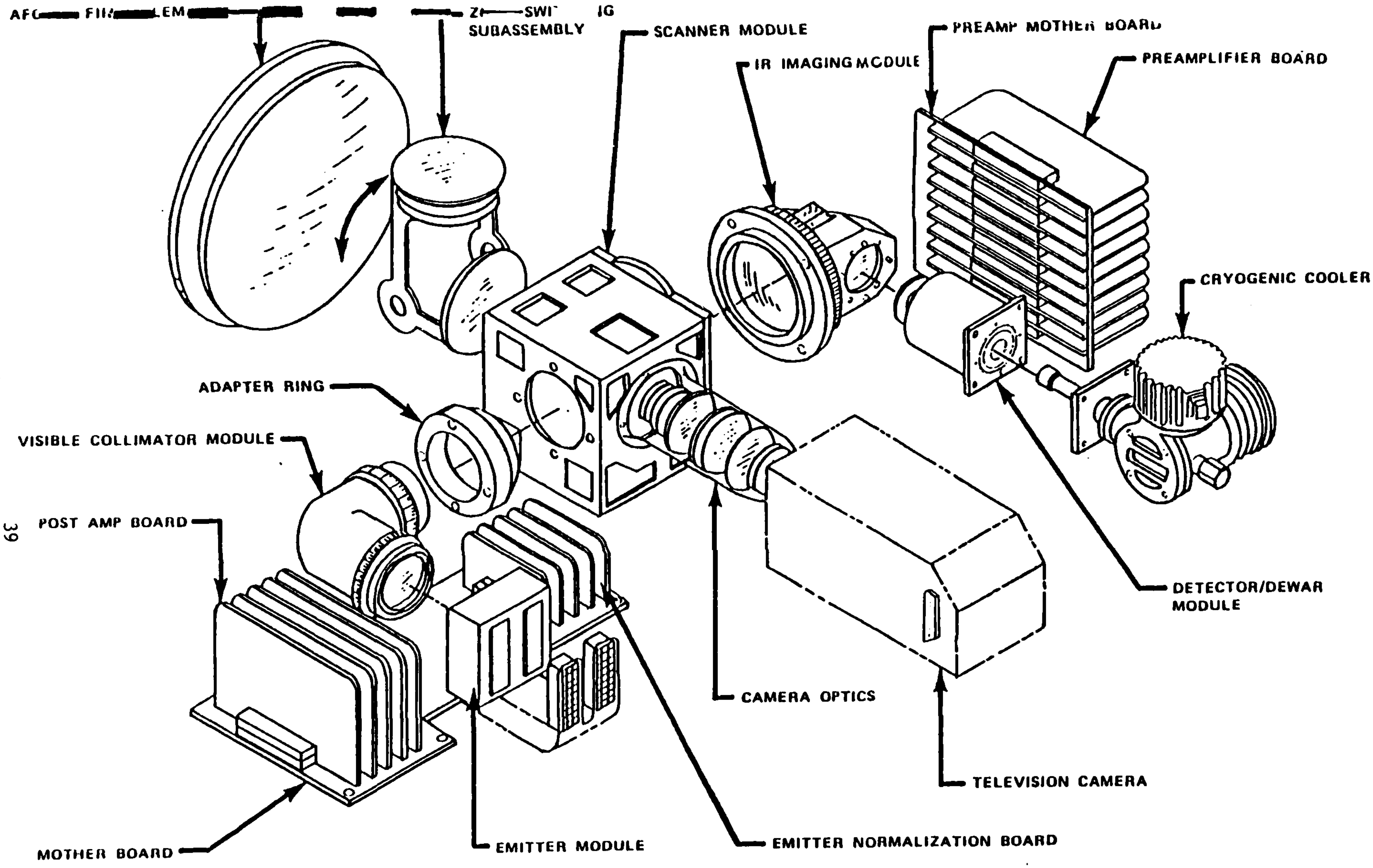


Figure 4 Modular FLIR System

This procedure is repeated for a number of BAR patterns and for a number of temperature differentials. The data is then analyzed to compare individual detector responses under the various conditions of illumination. Proper selection of temperature, geometry, and location of the BAR pattern provides data which not only characterizes the thermal imaging system, but also identifies fault location.

5.1.2.3 Problems Associated With Testing

Testing is tedious, yet requires a high level of attention to detail and moderate skill levels even though the analysis is performed by a computer. Further, if the computer is off-line, the test results are delayed by data-processing turn-around time. Typically the test requires:

- Collection of nearly 1000 data points
- Five to ten changes in the target which may require hours for restabilization
- Several hundred minor adjustments in the target optics
- Up to 24 hours of continuous testing

5.1.2.4 Target and Associated Optics

The target consists of a heated plate which is obscured by a second plate in which slots have been machined. The slotted plate operates at room ambient temperature. A temperature controller maintains a temperature differential between the two plates. Typically the slotted plate may be 15cm x 15cm. A collimator is required to focus this target on the input aperture of the infrared imaging system. The size of the target, the aperture of the optics, and other design considerations result in a collimator utilizing primary optics with apertures

of 25 to 30 cm and target to system path lengths on the order of 6 meters. Design and cost considerations result in large, heavy, optical test systems.

5.1.2.5 Environment and Personnel Control

Infrared imaging systems sense any variation in infrared energy at the input optics. Three of the most serious sources of test errors are as follows:

- Changes in equipment temperature
- Target drift in response to ambient temperature changes
- Radiation from the personnel

The first of these is controlled by design of the test facility and equipment; the second is controlled either through the use of absolute temperature control on the target case or by controlling the temperature of the test area. The personnel problem is the most critical of the three. It requires that extraneous personnel be excluded from the test area and that the test facility be designed to exclude the test equipment operator from the field of view during test. This latter is only partially successful due to the need to change target patterns and adjust the test optics.

Some of the infrared (thermal) imaging system specifications require that all maintenance which requires opening the optical assembly be accomplished in a clean room. This requirement could be met at the Direct Support/General Support (DS/GS) levels by laminar flow clean benches.

5.1.2.6 Potential Solutions to Test Problems

The testing is easily automated utilizing a small on-line computer. In one application in which a mini-computer was used for data processing and collection only, test times were reduced to less than eight hours and the time from test initiation to the first repair decision point was less than 20 minutes. The programming was done in Assembly language and the total memory capacity was 12K of 16 bit words.

This solution could be implemented in a dedicated microprocessor based tester which could operate either as a standalone unit or an adjunct to a large ATE system.

Additional recommendations for improving TMDE for IR imaging systems include:

- Built-In-Test (BIT) for IR Imaging System Electronics which will reduce maintenance.
- Affordable, quick automatic shading evaluation and adjustment of VIDICON's and CRTs.
- Modular Electro-Optical Test Set capable of testing IR Imaging Systems components independently.

5.2 Microwave Devices

The communication systems associated with the advanced Army weapon systems were surveyed in order to find the extent new technology microwave devices were in use. The types of radio sets in the surveyed weapon systems were all VHF/FM type with a frequency range of 30-75.95 MHz. No new technology microwave devices were utilized and therefore support requirements for the surveyed radio sets remain unchanged. In actuality, support requirements

for advanced Army weapon systems utilizing microwave devices will change dramatically. New test requirements will exist for measurements up to 100 GHz.

5.3 <u>VLSI/VHSIC (Very Large Scale Integration/Very High Speed Integrated Circuits)</u>

The microprocessors and memory chips used in the AAH weapon system can be adequately supported using EQUATE (AN/USM-410).

5.4 <u>Additional Support Equipment</u>

a. <u>Developed</u>

- <u>XM-1</u>

  DS - Thermal System Test Set (TSTS); Direct Support Electrical System Test Set (DSESTS)

- <u>TOW</u>

  AN/TAM-4 - Bottle Charging/Cleaning Static

  AN/TAM-3 - Night Sight Test Facility

b. <u>Under Development</u>

- <u>AAH</u>

  Electro-optical augmentation being developed to supplement the AN/USM-410

- <u>XM-1</u>

  Simplified Test Equipment (STE)

- <u>CFV and IFV</u>

  Modifications are planned to the STE-XM-1, DSESTS-XM-1 and EQUATE (AN/USM-410)

6. TRENDS OF NON-MILITARY TECHNOLOGY

6.1 Electro-Optics

6.1.1 Fiber-Optics

Fiber-Optic cable is presently being implemented instead of coaxial cables in many varying applications. Fiber-optic cable presents the following advantages over coaxial cable:

- Lower material cost ($0.48/meter)
- Smaller size and Weight
- Simplified Handling and Installation
- Increased Data Gathering Capabilities by a factor of a hundred
- Free of electromagnetic and radio frequency interference

Telephone systems are incorporating fiber-optic cable, instead of coaxial cable providing lower transmission losses and greater bandwidth capacity. Fiber-optic cable is immune to lightning strikes and shows minimal crosstalk or pickup problems.

Cable-TV application (CATV , community antenna television) are presently using fiber-optic cable carrying up to 25 TV channels with continuous cable runs of 2.2 km.

A fiber-optic communications system produced by Bell System Labs was introduced in 1979 by the Southern New England Telephone and Telegraph Co. It was the first fiber link for general use in a subscriber loop in the Bell System. The system utilizing FT-3 equipment, links a central

office in Trumbull, Conn. with a remote terminal servicing 192 customers initially.

A fiber-optic lightwave system was used for voice, data, and video service during the 1980 Winter Olympics. The Lake Placid telephone facility linked the telephone switching office, the Olympic ice arena, and the broadcast center serving 26 mass media agencies. The fiber-optic cable contained 12 fibers, six of which carried video and associated voice signals. The remaining six fibers were used as back-ups. Table 2 gives a breakdown of Bell System fiber optical links.

Nuclear power plants are using fiber-optic cable for their data transmission links, especially controls, due to interference immunity and radiation hardness.

Computer and industrial equipment interconnections are taking advantage of fiber optics to eliminate ground-loop and interface pickup problems. An example is the one kilometer Fujitsu optical fiber transmission system used at Keio University, Tokyo, Japan, that links two large scale computers. The large size of the computers demanded a high-capacity, high quality, high speed link, which the optical system provided. Also, use of the optical link precluded interference from a 60,000 volt power line nearby by using fiber cable which is free of electrical interferences.

6.1.2 Lasers

Semiconductor or injection laser (long wavelength) systems, using fiber optics, can transmit signals up to 50 km

Bell System Optical Link					
System	Cut-over	Fiber length (km)	Use	Bit rate+	Remarks
Chicago, IL	May, 1977	4 12	F T	DS-3	Experimental
Orlando, FA	Feb., 1979	15	F	DS-1	General trade
Phoenix, AZ	Oct., 1979	18	F	DS-3	General trade
Sacramento, CA	Oct., 1979	155	T	DS-2	Field trial
Trumbull, CT	Dec., 1979	156	F	DS-3	Prestandard FT3
Lake Placid, NY	Feb., 1980	50	F	DS-2	Custom
Bernal Heights, CA	Oct., 1980	270	T	DS-3	Prestandard FT3
Smyrna, GA	Dec., 1980	400	T	DS-3	Standard FT3
Pittsburgh, PA	Feb., 1981	2800	T	DS-3	Standard FT3
San Francisco, CA	April 1981	2000	T	DS-3	Standard FT3
White Plains, NY	June 1981	1300	T	DS-3	Standard FT3

F= Loop-feeder plant
T= Trunk plant

+DS-1=1.53 Mbits/s
DS-2=6.31 Mbits/s
DS-3=44.7 Mbits/s

TABLE 2 BELL SYSTEM OPTICAL LINKS

without repeaters. These laser communication systems provide high data rates, privacy, survivability, and resistance against EMI/RFI.

A specialized holographic camera, developed at the Department of Energy's Pacific Northwest Laboratory can capture photographically minute pollutant particles travelling through air. The camera utilizes a laser light source. As particles pass through the laser light beam, the interference pattern between light from the laser and light reflected from the particles is recorded on photographic film. When the film is developed, the resultant hologram provides a three-dimensional image under proper illumination.

The bulk of the industrial laser market concentrates on the following:

- Metal Hardening
- Marking
- Engraving
- Semiconductor Annealing

6.1.3 Imaging and Display Devices

Texas Instruments has been working on Infrared Focal Plane Technology using HgCdTe charge transform devices. Charge Coupled Devices (CCD) have been used as visible imaging sensors since their introduction in 1970. CCDs apply best to scanning systems where synchronously scanning the IR image with the charge packet increases signal levels while maintaining TV scan rate compatability. A light, ultra-compact solid-state color video camera in which the conventional image pickup tube is replaced with two charge-coupled devices has been developed by Japan's Sony Corporation. The camera has a resolution of 280 horizontal and 350 vertical lines.

6.2 Microwave Devices

New microwave hardware is being developed to operate in a new region of the microwave spectrum. For example, the first U.S. digital microwave radio system in the 18GHz band has been introduced by the Farinon Electric Co. of San Carlos, California. The microwave radio is applicable to common carrier, business communications, and industrial users sharing 18.36 to 19.04 GHz frequency bands.

Bell Northern Research of Canada has selected the 18GHz band to provide short haul telecommunication in rural areas. Also, an optical-fiber system is being used with microwave transmitters to carry analog video signals. Bell of Canada uses an optical connection between a satellite earth station and a terrestrial microwave tower. The earth station and microwave sites are joined by 3.7km of aerial cable containing light glass fiber.

6.3 VLSI/VHSIC

The semiconductor industry predicts VLSI circuits of 100,000 gate Random Access Memories (RAM) chips sometime this year and milliongate chips by the year 2000. RAMs have so far been the proving ground for VLSI chips. The question that introduction of VLSI chips raises is whether they will be a profitable replacement for LSI. The VLSI chip may be too complex for noniterated logic circuit, which have smaller markets and higher design costs. There is also the question whether Computer-Aided Design (CAD) will develop into the least expensive way to use mass-produced VLSI in arbitrary complex semi-custom designs.

The quest for VLSI surfaces with the growing demand for GHz or gigabit-per-second circuits for digital, video, and radar communication systems, as well as for microwave applications. Many of these applications are beyond the capabilities of silicon technology but may be satisfied by circuits using GaAs FETS.

The commercial industries' clouded future for VLSI/VHSIC circuits has caused the Department of Defense to initiate a six year program for development of Very High Speed Integrated Circuits (VHSIC). The emphasis of the program differs from the commercial VLSI thrust in the following areas:

- The VHSIC program will develop ICs for broad classes of military systems.
- These ICs will perform functions for which there is no urgent commercial or industrial need.
- VHSIC architectural concepts and techniques will

minimize the need for customized designs and therefore reduce costs.

- The ICs will increase real-time system throughput, which will require not only higher chip complexity, but also higher clock rates to achieve real-time signal processing.
- The VHSIC chips will satisfy military environmental requirements, such as performance over a wide temperature range, radiation exposure tolerance, and reliability.

A minimum clock speed of 25 MHz is a goal of the VHSIC program.

The VHSIC program calls for the construction and testing of subsystems that will allow the performance of military-related functions and missions previously precluded by computational limitations, size, weight, power, and reliability considerations - for example, high-throughput signal and data processing subsystems to be applied in such systems as military satellites, cruise missiles, fire-and-forget missiles, radar, command and control systems, wideband data communications, undersea search, electronic warfare, signal intelligence, targeting and fire-control systems, spaceborne data processing, and small, low-cost receivers for the new global positioning system satellites.

5.3.1 ATE for VLSI/VHSIC

With the introduction of VLSI, manufacturers of Automatic Test Equipment (ATE) are presently primed to match the pace set by advances in LSI components. The large scale integration of components mandates higher speeds and throughput for ATE, especially to deal with significant increases in memory capacity. Representatives of the Takeda Riken Industry Co. (Japan) and the Musashino Electrical Communications Laboratory of Nippon Telegraph and Telephone (Japan) described a prototype 100MHZ system at the 1979 IEEE Test Conference in Cherry Hill, New Jersey.

Fairchild Test Systems (San Jose, CA.) also addresses these problems of LSI component testing with its Series 20 general-purpose LSI test system. Handling high-speed, 20-ms RAM and 10-k ECL, the Series 20 runs 20MHz on all of its test pins. Thirty test pins also operate at 40 MHz. These capabilities greatly expedite tests and should improve throughput.

Increased complexity at the component level multiplies testing problems at the PC board level. More and more solutions lean on advanced software to produce the test programs required at the board level.

For instance, the Capable 4814 automatic test-generation system, recently announced by Computer Automation (Irving, CA), uses test-generation software to improve test speeds by an order of magnitude. A test-generation facility from Teradyne (the LF780 LASAR) also incorporates new software modeling techniques. It generates complete test programs for

complex PC boards in a fraction of the time previously required for less intricate boards. These enhancements will soon be joined by improved gate simulation of microprocessors and of LSI peripheral chips.

Another area ripe for new developements is testing with Signature Analysis (SA), the cyclic-redundancy-check technique developed by Hewlett-Packard (Palo Alto,CA). In-depth cause-and-effect analysis using SA makes it possible to find a fault in a feedback loop without opening the loop. GenRad (Concord, MA) first offered closed-loop field troubleshooting of PC boards in its 2225 test system.

Appendix A

General Description of

Major Advanced Army Systems

GENERAL DESCRIPTION OF MAJOR ADVANCED ARMY SYSTEMS

A. <u>Advanced Attack Helicopter (AAH)</u>

The AAH (YAH-64A) is a two-place, tandem-seat, twin-engine helicopter with four-bladed main and anti-torque rotors. Tandem seating arrangement is used to minimize frontal area. The copilot/gunner is placed in the forward location to maximize target acquisition, navigation teamwork and weapon response time. The pilot in aft cockpit is elevated above the copilot/gunner to maximize visibility from the rear location. The helicopter is powered by two 1500 HP General Electric T700-GE-700 turboshaft engines with a low-loss, "Black Hole Ocarine (BHO)" IR supression system. The AAH main rotor is 48 feet in diameter, fully articulated with elastomeric lead-lag campers. The blades incorporate -9^{o} twist and operate at a tip speed of 726 fps. The anti-torque rotor is 8 feet 7 inches in diameter. The blades are mounted on teetering hubs and are separated angularly at 55^{o} (rather than 90^{o}) for noise reduction. The YAH-64A incorporates a movable horizontal stabilizer. Two flight control systems are employed: a mechanical wing flap control, provided to enhance maneuverability, and a fly-by-wire backup control system. The armament system is comprised of a 30mm lightweight (chain gun) weapon mounted in a flexible turret on the underside of the forward fuselage, a 2.75 inch rocket system and the HELLFIRE Modular Missile System (HMMS) point target subsystem mounted on the wing stations. The fire control system consists of the Target Acquisition Designation Sight (TADS) and Pilot Night Vision Sensor (PNVS); two Integrated

Helmet and Display Sight Subsystem (IHADSS); air data system; fire control computer; and the necessary controls and displays required to fire the weapon. TADS includes a low-light-level TV, a Forward-Looking Infrared (FLIR) device, and direct viewing telescope optics for target acquisition. Within TADs, there is also a laser range finder and a laser target designator to guide HELLFIRE missiles. PNVS includes FLIR device for nap-of-earth flying capability.

The armament and fire control subsystems are operated on a Multiplex Data Bus Subsystem (MDBS) for improved reliability and redundancy as well as reduced weight. The avionics suite includes a Lightweight Doppler Navigational System (LDNS), an Identification Friend or Foe (IFF) transponder system, a radar warning system and a standard set of communication and secure voice equipment. A Fault Detection and Location System (FD/LS) provides a means to test subsystems and fault isolate to the line replaceable unit level.

The YAH-64A provides direct aerial fire against a wide variety of enemy tactical targets and primarily provides a highly mobile tank killing capability. The YAH-64A is capable of operation throughout the forward battle area at minimum altitudes under day, night, and adverse weather conditions. The primary mission payload for the YAH-64A is eight HELLFIRE missiles and 320 rounds of 30mm ADEN/DEFA ammunition, With this payload, it will have the following performance under 4,000 feet/95°F conditions at primary mission gross weight; (1) 450 feet per minute vertical rate of climb from a hover out of ground effect (HOGE) at 95% intermediate rated power, (2) 1.83 hours endurance, and (3) 145 KTAS cruise speed.

The YAH-64A is designed to be survivable to an impact of a 23mm round on the aircraft basic structure and main rotor blades. Trans-

parent armor is placed between the pilot and copilot to prevent incapacitation of both from a single 23mm fragmentation round. Aircraft flight controls are made redundant and located so that no single 12.7mm round can destroy both primary and secondary systems. The main transmission and gear boxes have a 30-minute run-dry capability. Survivability design features include integral exhaust plume suppression and hot metal cooling to counter the infrared missile threat. In addition, the aircraft has crashworthiness features, i.e., crashworthy fuel cells, foam in the fuel cavity, fire-resistant hydraulic fluid and crashworthy crew seats.

B. XM-1 Main Battle Tank

The XM-1 (See Figure 5), the U.S. Army's first turbine-powered main battle tank, has twice the power, cross country speed and mobility of current U.S. combat tanks. The 60 ton vehicle incorporates significant advances in crew protection, firepower, durability, reliability, agility, and maintainability.

A 1500 horsepower regenerative turbine engine provides the power for the XM-1. This quiet, smokeless, multi-fuel engine permits the tank to travel at 45mph on hard surfaces and move cross country at speeds in excess of 30mph. The turbine has significant advantages over present diesel tank engines in the areas of performance, durability and reduced maintenance. Nearly a ton lighter than a comparable diesel, at maturity the turbine is expected to operate up to 12,000 miles without requiring overhaul, or nearly 2 1/2 times longer than other production tank engines. The turbine never requires an oil change and is capable of operating on a wide range of fuels to include diesel, jet fuel and gasoline. Approximately 70 percent

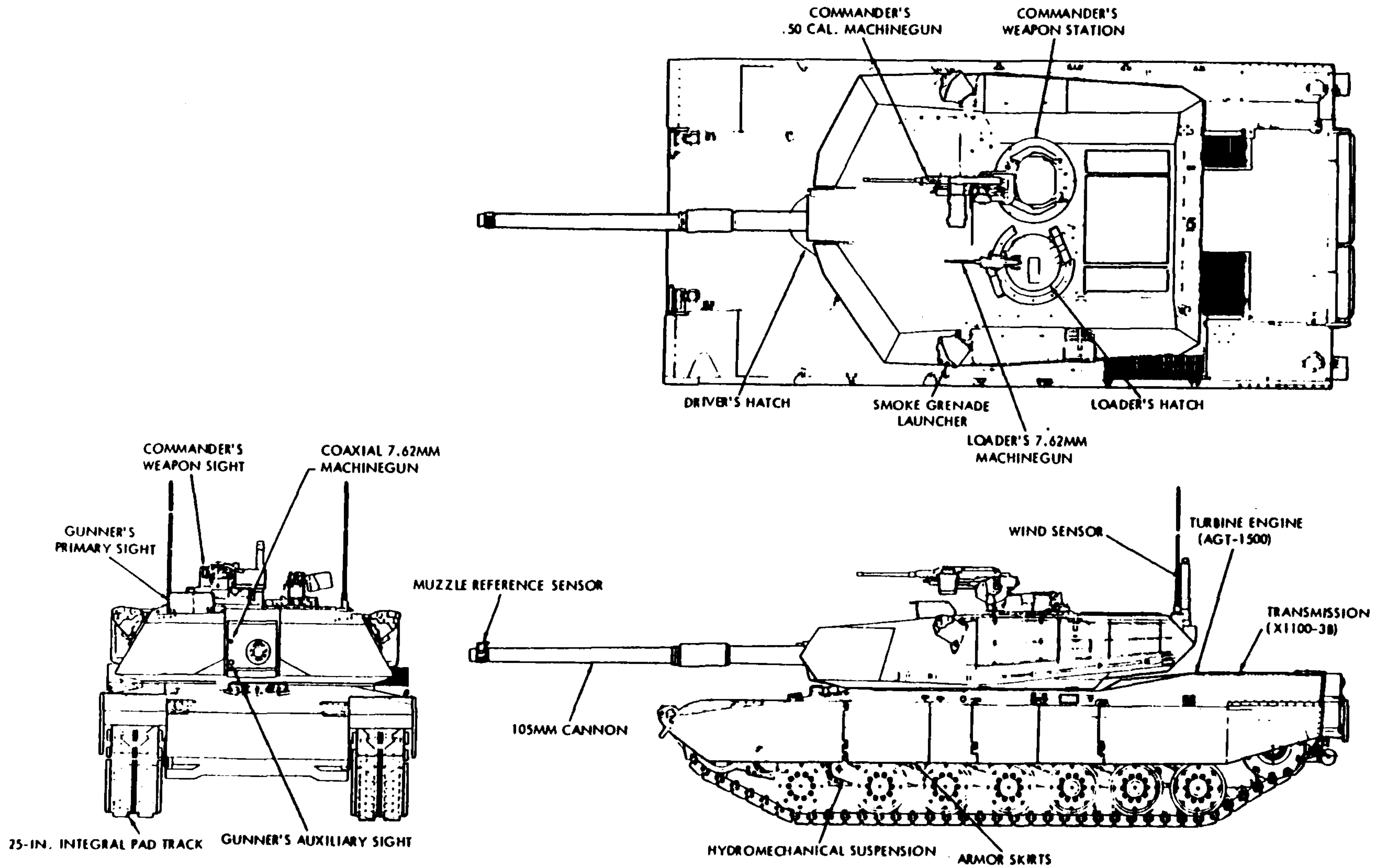


Figure 5 XM-1 MAIN BATTLE TANK

of the engine accessories and components can be removed without removing the power pack from the tank. When required, the entire power pack can be removed and reinstalled in less than 60 minutes as compared to four hours for current U.S. tanks. The turbine combines with an automatic hydrokinetic transmission to provide four speeds forward and two in reverse. The transmission also provides integral brakes, variable hydrostatic steering and pivot steering.

The primary design characteristic of the XM-1 Tank is the revolutionary protection provided for the four man crew. In addition to offering a significantly reduced silhouette on the battlefield due to a low height of only 93.5 inches, the XM-1 incorporates advanced armor techniques which are highly effective against antitank missiles and other current and projected battlefield threats. Unique survivability measures are also evident inside of the vehicle. The crew fighting compartment is completely seperated from the fuel tanks by armor bulkheads. Sliding armor doors and spall-protected boxes isolate the crew from on-board main gun ammunition. This compartmentation of fuel and ammunition markedly decreases the probability of catastrophic explosions and enhances the survivability of the crew and the tank system on the modern battlefield where hits can and must be expected. An automatic Halon fire extinguisher system in the tank reacts to the outbreak of fire in 3 milliseconds; extinguishing fires in less than 2/10ths of one second.

The suspension system, which provides the XM-1 the capability to traverse cross country terrain at unprecedented speed, emphasizes simplicity throughout as evidenced in the simple but effective rotary shock absorbers. New torsion bars incorporate recent advances in metallurgy while retaining the basic design proven in operational use since

World War II. This suspension system, employing a 15 inch road wheel travel as compared to 6.4 inches in current U.S. tanks, in combination with the turbine engine and resulting high horsepower to ton ratio of approximately 25:1, gives the XM-1 the vastly superior cross country mobility, agility and crew ride essential for combat effectiveness on tomorrow's battlefield.

The fire control system, integrating a 105mm cannon firing a new, improved family of kinetic energy ammunition, laser range finder, full solution solid state digital computer and stabilized day/thermal sights, has also been simplified for ease of operation and has a much enhanced first round hit probability. The tank's stabilization system permits accurate firing-on-the-move: the gunner merely places his reticle on the target and uses the laser to determine the range; the computer determines and applies the weapon sight offset angles necessary to obtain a target hit. All the gunner then needs to do is squeeze the trigger. The turret structure itself has been designed to accommodate the American produced version of the German 120mm smooth bore gun system without major modifications.

The interior of the crew fighting compartment has been designed to allow the crew to function with maximum effectiveness over prolonged periods of operation. The commander's station provides excellent visibility without exposure. The driver's station allows the driver to operate the vehicle from a semi-reclining position with excellent closed-hatch visibility. Motorcycle-type steering and throttle controls allow for agile maneuvering and facilitate driver training. The positions of the gunner and loader have been engineered to make them especially effective during sustained combat

and difficult cross country operations.

Technical characteristics of the XM-1 tank is given in Table 3.

Table 3 XM-1 Technical Characteristics

Crew	4 men
Combat Weight	60 Tons
Ground Pressure	13.3 psi
Width	144 inches
Height (To Turret Roof)	93.5 inches
Ground Clearance	19 inches
Maximum Speed	45 mph (Governed)
Agility (HP to Ton Ratio)	25:1
Acceleration (0-20mph)	7 seconds
Sustained Speed	
60% slope	5mph
10% slope	20mph
Obstacle Crossing	
Vertical Wall	49 inches
Horizontal Trench	9 feet
Fording	48 inches (unprepared) 93.5 inches (prepared)
Power Package	1500 HP Air Cooled Regernative Turbine/ Automatic Hydrokinetic Transmission with 4 forward and 2 reverse speeds
Fuel	Diesel Fuel (DF2) 492 Gallons (usable) 508 Gallons (total)
Operating Range	275 miles
Turret	Dual Capable 105/120mm Gun System
Primary Weapon	105mm Rifled Cannon (M68
Coaxial Weapon	7.62mm Machine Gun (M240)
Loader's Weapon	7.62mm Machine Gun (M240)

Table 3 cont'd

Commander's Weapon	Caliber .50 Machine Gun (M2)
Range Finder	Neodymium YAG Laser (200-7990 meters)
Ballistic Computer	Digital, Solid State
Reduced Visibility Capability	Thermal Imaging
Stabilization	
Azimuth Axis	Turret
Elevation Axis	Sight
Ammunition Storage	
105mm	55 rounds
7.62mm	11,400 rounds
Cal .50	1,000 rounds
Smoke Generation	M250 Grenade Launcher Integral Engine Smoke Generator

C TOW (Tube Launched, Optically-Tracked, Wire Guided) Heavy Antitank Missile

TOW is an acronym for Tube-launched, Optically-tracked, Wire-guided, and describes a heavy assault ground-to-ground (or air-to-ground) antitank guided weapon system. In production since, 1969, the TOW has become one of the most important weapons in the U.S. inventory, a key to overcoming the Warsaw Pacts' numerical superiority in armor.

The TOW launcher system, for infantry use, is made up of five elements none of which weighs more than 24kg, although the complete launcher weighs 78kg when assembled and ready to fire. Four of these elements are a tripod and a traversing unit, mounted upon the tripod, to which the tripod launch tube and optical sight are attached. The gunner's optical sight is of high magnification and equipped with aiming cross-hairs which when combined with the smooth, stable motion of the traversing unit permit very accurate tracking of moving targets after very little operator training. The fifth individual element is the electronic guidance computer which sends steering commands automatically to the missile in flight.

The two-stage, 43 pound BGM-71A missile contains two solid propellant motors. The launch motor ejects the missile from the launch tube and is burned out by the time the missile has left the tube. Only after the missile has flown approximately 60 meters does the flight motor ignite, so that no protection is necessary for the gunner against hot exhaust gas and propellant particles. The flight motor is mounted in the center of the missile with its two exhaust nozzles mounted on either side. This arrangement pre-

vents interference with the guidance wires which are placed at the end of the tail of the fuselage. Steering commands are transmitted by the two wires which uncoil from two seperate spools. Cruciform, short wings in the center of the missile and the cruciform rudder surfaces all unfold after leaving the launch tube. Missile maneuvering is done entirely aerodynamically (without jet vanes) so that TOW maintains good maneuverability throughout missile flight. The electronics unit is mounted between the flight motor and the armor-piercing warhead.

After the missile leaves the launch tube, a light source in the tail comes on so that the optical sensor on the launcher, which is bore-sighted with the gunner's telescope, can track the missile along its flight path. The light source is sufficiently strong to allow automatic guidance to the maximum range of the missile under all conditions in which the target is visible to the gunner.

Recent improvements to the TOW include the AN/TAS-4 thermal-imaging infrared night sight, developed by Texas Instruments, which allows full use of the system in darkness, as well as some capability in smoke, haze or against camouflage. The launch tube has also been shortened to reduce the effects of high winds, and the infrared data link has been "hardened" to reduce susceptibility to countermeasures.

TOW can also be installed in most of the available wheeled or tracked vehicles capable of cross country travels. TOW anti-tank missiles can be launched from the following U.S. Army weapon systems:

- XM-2 Infantry Fighting Vehicle (IFV)
- XM-3 Calvary Fighting Vehicle (CFV)

- AH-IS Huey Cobra Helicopter
- TOW ground launcher (Infantry use)
- XM 901 Improved TOW Vehicle (ITV)
- UH-1B Huey Cobra Helicopter
- M 113 Armored Personnel Carrier

TOW Technical Characteristics

Military Designation: BGM-71A

Type: Heavy anti-tank guided weapon system

Guidance principle: Automatic missile tracking and command guidance from optical tracker

Guidance Method: Wire guidance control of gas-operated aerodynamic tail surfaces

Propulsion: Two-stage solid-propellant motor. First stage quadruple; second stage single. Recoilless launch

Warhead: High-explosive shaped charge armor piercing

Missile length: 117 cm

Missile diameter: 15.2 cm

Launch weight: 18 kg.

System weight: 102 kg. including one missile

Speed: Believed to be at least 1000km/h

Range: Minimum: 65m
Maximum: 3750 m

Rate of fire: Three launches in 90sec.

D. Fighting Combat Vehicle Systems

The Fighting Combat Vehicle Systems family includes the XM-2 Infantry Fighting Vehicle (IFV), the XM-3 Cavalry Fighting Vehicle (CFV), and the General Support Rocket System (GSRS) carrier. The XM-2 and XM-3 give the U.S. Soldier the mobile armor-protected fighting capability, and the GSRS provides mobile long-range artillery rocket support.

The XM-2 will enable the infantry to work closely with armor units equipped with the XM-1 tank and the XM-3 will provide the cavalry with the mobility and firepower needed to accomplish its various missions.

Features common to both XM-2 and XM-3 vehicles include:

- A two-man turret, mounting an externally powered 25mm automatic cannon, a two-missile TOW launcher, and an M-240 (MAG58) 7.62 coaxial machinegun.
- Stabilized all-electric turret drive.
- Stabilized day and night sight.
- Periscopes and sights for 360-degree vision for the vehicle commander.
- Spaced laminate armor.
- A turbocharged, 500-hp diesel engine.
- An automatic hydro-mechanical transmission.
- An improved suspension that permits 14-in. vertical travel of the road wheels.

The XM-3 CFV is identical to the XM-2 IFV (see Figure 6) in external appearance, but the interior is configured for a five-

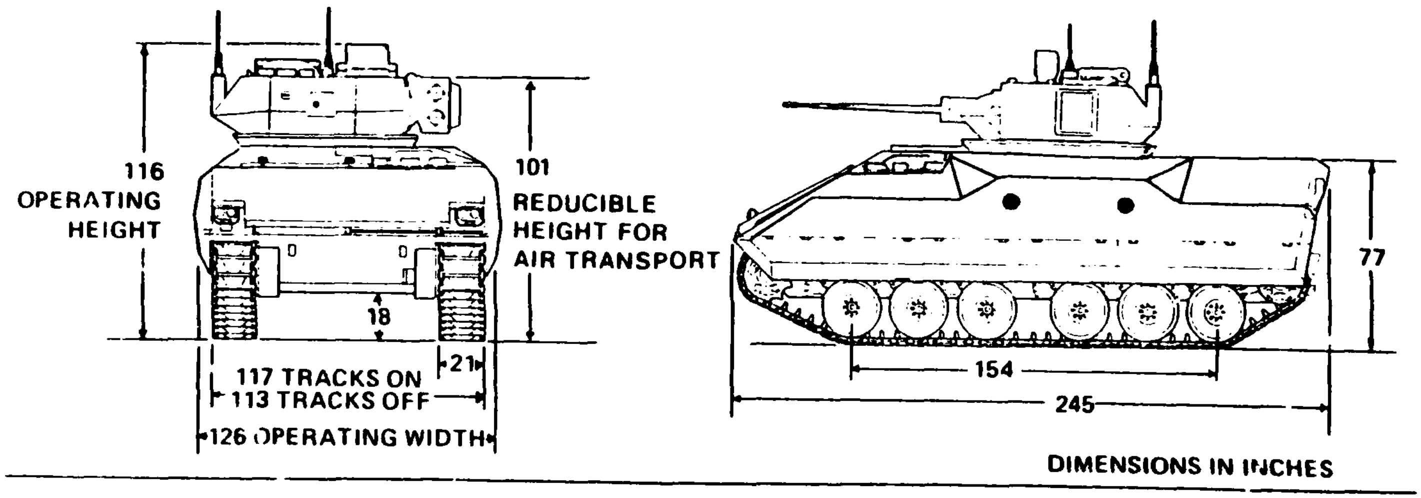


Figure 6

XM-2(3)

man scout crew and stowage of 10 TOWs and more 25mm and 7.62mm ammunition than is carried in the XM-2.

Mobility is assured by the turbocharged, 500-hp diesel engine which provides a power-to-weight ratio of 21.28 hp per ton and an acceleration rate of 0 to 30 mph in approximately 19 seconds.

Increased survivability for this family of fighting vehicles is achieved with spaced laminate armor that gives maximum protection for minimum weight. Although the XM-2 and 3 are relatively light compared to tanks, their armor can defeat 91 percent of the types of anti-armor attacks that may be encountered on the battlefield.

Table 4 gives the technical characteristics of the XM-2 and XM-3.

The Ground Support Rocket System (GSRS) carrier fires 230mm rockets out to ranges beyond 30,000 meters. The GSRS consists of a 12-tube launcher mounted on a lightly armored tracked carrier derived from the chassis of the infantry and cavalry fighting vehicles. The launcher, which tilts, swivels and elevates on the carrier bed, is loaded with two disposable, six round rocket pods of rectangular cross-section.

The carrier has a three-man crew, riding in an aluminum armored cab with transparent armor windows fitted with louver covers. A complete fire mission can be accomplished without the crew leaving the cab. Complete with loaded rocket launcher, the vehicle is expected to weigh about 25 tons, with a range of 300 miles at 25mph and a top speed of 40mph.

By using IFV components, development and production costs of the GSRS carrier will be greatly reduced. Additionally, training for the operation and maintenance of all the fighting vehicles will be identical and repair parts for the three versions will be interchangeable.

Table 4 XM-2 and XM-3 Technical Characteristics

Weight combat loaded	47,000 lb	21,319 kg
Weight, less fuel, crew and OVE	40,650 lb	18,439 kg
Weight, air transportable	41,000 lb	18,598 kg
Ground pressure, combat loaded	7.4 psi	0.52 kg/cm^2
Personal capacity, IFV	9	
CFV	5	
Fuel tank capacity	175 gallons	662 liters
Performance		
Speed on land	41 mi/h	66 km/h
Speed in water, with track	4.5 mi/h	7.2 km/h
Cruising range	300 mi	483 km
Turning radius	Pivot to infinite	
Slope	60%	
Side slope	40%	
Trench crossing	100 in	254 cm
Vertical wall climbing	36 in	91 cm
Gross horsepower-to-weight ratio	21.28 hp/ton	
Engine		
Make and model	Cummins VTA-903	
Displacement	903 in^3	14.8 liter
Type	4 cycle	
Fuel	Diesel	
Gross horsepower	500	506 metric
Transmission, Automatic		
Make and model	GE HMPT-500	
Type	Hydromechanical	
Steering	Hydrostatic	
Brake type	Multidisc, oil cooled	
Running Gear		
Suspension type	Return roller	
Springing media	Torsion bar	
Number of wheels	6 pr. per side	
Wheel size	24 in diam	61.0 cm
	4 in wide	10.2 cm
Track type	Steel single pin with detachable rubber pad	
Shock Absorbers	4 per side	
Number of shoes	83, left; 82 right	
Track pitch	6 in	15.2 cm
Track width	21 in	53.3 cm
Night Vision Equipment		
Sight, gunner	Thermal imagery	
Sight, commander	Optical relay from gunner's sight	
Sight, driver	AN/VVS-2	

Table 4 cont'd

Electrical System

Generator

Amperes............................220

Volts, dc..........................28

Batteries..........................4,type 6TN,100 amp-hr,12-volt each

Turret (Two-Man)

Armament...........................25mm automatic cannon, TOW missile launcher 7.62mm, M240 machine gun

Traverse...........................360 deg. continuous

Elevation

25mm cannon and 7.62mm machine gun........................+60 deg to -10 deg

TOW missile launcher..............+30 det to -20 deg

Slew rate, maximum

Elevation and traverse............60 deg/sec

Tracking rate, minimum.............0.05 mil/sec

Stabilization system...............Electric

Ring gear, pitch diameter..........60 in

Squad Weapons

Firing port weapon, XM231, 5.56mm IFV only..........................6, ball-mounted

Machine gun, M60, 7.62mm...........1

Rifles, M16A1, 5.56mm..............9, IFV
5, CFV

Ammunition

	IFV ready/stowed	CFV ready/stowed
25mm	300/600	300/1200
7.62mm (XM240)	800/1400	800/3600
7.62mm (M60)	2200 stowed	3200 stowed
5.56mm (firing port)	1800/2200	NA
5.56mm (M161A)	2160 stowed	1460 stowed
TOW missiles	2 in launcher	2 in launcher
TOW/Dragon missiles	5 stowed, any combination	10 TOW stowed
LAW (M72A2)	3 stowed	NA

Communications (Commander Vehicle)

Radio, IFV......................... AN/VRC-46, 1 set
AN/GRC-160, 1 set

Radio, CFV......................... AN/VRC-12, 1 set
AN/PRC-77, 1 set

FM Sets

Armor

Top and front slopes............... 5083 aluminum

Vertical sides and read............ Spaced laminate armor

Bottom............................. 5083 aluminum with antimine applique (IFV only)

Side Slopes........................ 7039 aluminum

E. High Energy Laser Systems and Particle-Beam Weapon Systems

The U.S. Army High Energy Laser and Particle-Beam Weapon Systems are generally related to antiballistic missile applications. The basic Army particle-beam technology programs are:

- Austin Research Associates' proof-of-principle autoresonant accelerator designed to produce charged-particle beams of high-intensity, high energy ions. The technology could lead to compact weapons designs for ballistic missile defense.

- Los Alamos Scientific Laboratory White Horse program designed to provide a negative hydrogen beam that is accelerated and neutralized by passing the beam through a charge-exchange cell. Such a device would be based in space, where neutral beams are considered desirable to intercept ballistic missile targets before nuclear warheads separate or re-enter the earth's atmosphere.

As part of the directed-energy weapons overall program, the Army will continue modest high-energy laser weapons technology, especially in areas related to kill mechanisms and vulnerability. Emphasis will be on the interaction of lasers with ballistic missile boosters. Tests will be conducted on boosters skins of varying thicknesses and hoop stresses to determine energy levels required for destruction. A by-product of this technology is the development of laser weapons countermeasures.

A second high-energy laser development area is device technology to push the state-of-the-art in developing lasers of shorter wavelengths.

There are three principal types of laser devices in experimental development:

- Bell Aerospace tin-oxide chemical laser. The Army believes this device can be scaled to high power levels with a demonstration scheduled in about three years. In the experiment, tin atoms are generated and nitrous oxide injected. The reaction provides tin-oxide in an excited state that lases to produce short wavelengths with the efficiency of a chemical laser. This is a visible device that operates at 0.5 microns.

- Westinghouse electric discharge excimer laser, a low-weight, low-volume device. A low-power demonstration already has been completed, and the device is being scaled to higher power outputs. This device is in the rare gas halide category using xenon-fluoride with a small X-ray source, to start the process. Once the X-ray starts the source, the electrical field sustains the discharge.

- Calspan vibrational electric transition laser device. Energy is pumped into a dissociated energy gas, like nitrogen or carbon monoxide. In Army experiments, an electron beam is used as the energy source in a gas mixture with a low electron level that matches the vibration levels of the heated gas.

The mixtures are gases like nitrous oxide and a cyanogen. Experiments are presently in progress.

The technology in the neutral beam White Horse program is aimed at providing a space-based particle-beam capability. The White Horse program is structured to provide high-quality negative ions, and good progress has been made in laboratory experiments. A radio frequency linear accelerator is being used, scaled for low-energy experiments.

White Horse physics experiments have been conducted using some bench systems hardware to discover boundaries of the technology. The equipment experiments are needed to produce a charged beam from which a neutral beam is derived.

A 5 Mev. test stand accelerator is being built in the Los Alamos laboratory, but funding cuts will delay construction for approximately two years. The test stand is a negative hydrogen accelerator designed to verify injector and accelerator concepts. This is the first phase of a two-phase effort. The second part is to build a 50 Mev. test accelerator to produce high energy. From that device the U.S. could extrapolate to 500 Mev. machines that move into the particle-beam weapons category.

The Army's two particle-beam technology programs will be moved to the Defence Advanced Research Projects Agency (DARPA).

Appendix B

Sample Questionnaire for

TMDS TECHNOLOGY SURVEY

QUESTIONNAIRE FOR TMDS TECHNOLOGY SURVEY

THE QUESTIONNAIRE IS DIVIDED INTO FOUR SECTIONS:

1. GENERAL INFORMATION
2. ELECTRO-OPTICS
3. MICROWAVE-DEVICES
4. VERY LARGE SCALE INTEGRATED CIRCUIT APPLICATIONS AND ARCHITECTURE

PLEASE ANSWER EACH QUESTION, FILL IN "UNKNOWN" IF NOT KNOWN, "N.A." IF NOT APPLICABLE OR "PROPRIETARY" IF THE INFORMATION CANNOT BE DISCLOSED. ALSO PLEASE FILL IN BELOW THE DATE AND THE NAMES OF THE PERSONS ANSWERING THE QUESTIONS.

QUESTIONS WERE ANSWERED BY:

NAME: ______________________ DATE: ______________________

NAME: ______________________

ADDRESS: ______________________

____

PHONE #(commercial) ____________

1. GENERAL INFORMATION

1.1. NAME OF WEAPON SYSTEM:

1.1.1 PRESENT NAME: ____________________

1.1.2 FORMER NAMES: ____________________

1.2 COMPANY SUPPORTING IT:

1.2.1 COMPANY NAME: ____________________

1.2.2 ADDRESS: ____________________

____

1.2.3. PERSON TO CONTACT-TECHNICAL

NAME: ____________________

MAILSTOP: ____________________

TELEPHONE #: ____________________

1.2.4. PERSON TO CONTACT-MARKETING

NAME: ____________________

MAILSTOP: ____________________

TELEPHONE #: ____________________

1.3. CAN THEY BE CONTACTED? ____________________

1.4. WHAT IS THE ANTICIPATED SCOPE OF DEPLOYMENT?

____

1.5. WHAT IS THE ANTICIPATED TIME FRAME FOR DEPLOYMENT?

____

____

1.6. GENERAL DESCRIPTION OF WEAPON SYSTEM

1.7. PRIMARY APPLICATION OF WEAPON SYSTEM

1.8. OTHER GENERAL INFORMATION (EXPLAIN):

2. ELECTRO-OPTICS

2.1 CIRCLE ON THE LIST PROVIDED TECHNOLOGICAL AREAS WHICH ARE TO BE UTILIZED IN THE SUBJECT WEAPON SYSTEM.

a. Fiber-Optics
   1 Transmitters
   2 Receivers
   3 Switches
   4 Cable
   5 Repeaters

b. Lasers
   1 Blue Green
   2 Chemical (EX. CO_2)
   3 Metal Vapor
   4 Gas
   5 Solid-State
   6 Dye
   7 Integrated Optics
   8 Fiber Optics
   9 Injection
   10 Ring Laser Gyros
   11 Radar
   12 Optical Communications
   13 Designators
   14 Rangefinders

c. Imaging and Display Devices
   1 IR Photoconductors
   2 IR Photovoltaics
   3 IR Photoemitters
   4 IR Focal Plane Arrays
   5 Coolers
   6 CCDs
   7 Intensifier Tubes
   8 Microchannels
   9 Electroluminescent
   10 Liquid-Crystal Displays

2.1.1 WHAT OTHER TYPES OF ELECTRO-OPTICAL TECHNOLOGY WILL BE USED ON THE WEAPON SYSTEM WHICH IS NOT IN THE PROVIDED LIST? ____________

____

____

2.2 HOW IS THE PERTINENT TECHNOLOGY UTILIZED IN THE WEAPON SYSTEM?

____

____

____

____

____

____

____

2.3 IS THE CURRENT ARMY TEST EQUIPMENT ADEQUATE TO SUPPORT THIS NEW TECHNOLOGY? ____________________

2.3.1 IF IT IS, HOW IS IT BEING SUPPORTED? (SPECIFY SYSTEM AND AREAS OF SUPPORT)

____

____

____

2.3.2 IF NOT, CAN CURRENT ARMY TEST EQUIPMENT BE ADAPTED TO SUPPORT THIS NEW TECHNOLOGY? EXPLAIN

____

____

____

2.3.3 IF IT IS NOT ADAPTABLE, IDENTIFY SUPPORT EQUIPMENT PROPOSED FOR THIS NEW TECHNOLOGY?

____

____

____

2.4 IN DEALING WITH THE TESTING OF LASER RANGEFINDER/DESIGNATOR OPTICAL SUB-SYSTEMS COMMON PRACTICE INCLUDES THE LASER AND THE DETECTOR AS PART OF THE SUB-SYSTEM.

WITHIN THE CONSTRAINTS OF THE DEFINITION, THE MAJOR TESTS MEASURE:

a- Output power

b- Beam dispersion

c- Beam pattern

d- Detector sensitivity

e- Boresight (receiver to transmitter)

2.4.1 WOULD YOU PREFER A DIFFERENT DEFINITION OF THE OPTICAL SUB-SYSTEM? IF SO WHAT DEFINITION AND WHY?

____

____

____

2.4.2 ARE THE MEASUREMENTS DEFINED IN ACCORDANCE WITH YOUR PRACTICE? IF NOT WHAT ARE THE DIFFERENCES?

____

____

2.4.3 WHICH OF THESE MEASUREMENTS ARE REQUIRED AT THE DS/GS LEVEL?

____

____

2.4.4 WHAT CHANGES IN THE DS/GS TMDE WOULD RESULT IN IMPROVED LOGISTIC SUPPORT OF THESE EQUIPMENTS?

____

____

2.5 A MAJOR CONSIDERATION IN TESTING LASER RANGEFINDERS AND DESIGNATORS IS THE ESTABLISHMENT OF LASER SAFETY DURING TESTING. WHAT ARE YOUR RECOMMENDATIONS IN THIS AREA?

____

____

____

____

____

2.6 TWO MAJOR AREAS OF CONCERN ARE COMMONLY ENCOUNTERED IN DISCUSSIONS OF THE TMDE ASSOCIATED WITH INFRA RED IMAGING SYSTEMS.

a. THE SIZE, WEIGHT, AND MAINTENANCE/CALIBRATION REQUIREMENTS OF THE TEST OPTICS.

b. THE TIME REQUIRED TO TEST THE OPTICAL SUB-SYSTEMS INCLUDING THE DETECTIVE ARRAY.

CONSIDERING THE AREAS OF CONCERN FROM THE VIEWPOINT OF DS/GS TMDE:

2.6.1 DOES YOUR EXPERIENCE INDICATE THAT THESE ARE MAJOR AREAS OF CONCERN?

____

____

2.6.2 WHAT OTHER AREAS ARE OF EQUAL OR GREATER CONCERN?

____

____

2.6.3 WHAT TMDE RESEARCH AND/OR DEVELOPMENT IF ANY WOULD YOU RECOMMEND? ______________________________

____

____

2.7 A LARGE AMOUNT OF DATA IS AVAILABLE ON THE DEVELOPMENT OF PYRO-ELECTRIC VIDICONS, VERY LARGE DETECTIVE ARRAYS AND OTHER DETECTION SYSTEMS WHICH PROMISE TO ELIMINATE THE MECHANICAL SCANNING CURRENTLY USED IN IR IMAGING SYSTEMS.

2.7.1 TO WHAT DEGREE WILL THESE NEW DEVICES AFFECT THE DS/GS TMDE REQUIREMENTS WITHIN THE 1980-1990 TIME SPAN?

2.7.2 WHAT OTHER TECHNOLOGICAL CHANGES IN IR IMAGING SYSTEMS WILL IMPACT DS/GS TMDE IN THIS TIME FRAME?

2.8 THE OPTICAL SYSTEMS ASSOCIATED WITH LOW LIGHT IMAGING SYSTEMS ARE COMMONLY CONSIDERED TO BE SIMPLY AN EXTENSION OF STANDARD VISIBLE LIGHT OPTICS.

2.8.1 IN YOUR EXPERIENCE IS THIS A VALID ASSUMPTION?

2.8.2 WHAT DEVELOPMENTS IN DS/GS TMDE WILL BE REQUIRED TO SUPPORT THE ANTICIPATED IMPROVEMENTS IN THESE SYSTEMS FOR THE 1980-1990 TIME FRAME?

2.9 PLEASE LIST ANY AREAS IN WHICH YOU FEEL RESEARCH AND/OR DEVELOPMENT EFFORT IS NEEDED TO IMPROVE DS/GS TMDE EFFECTIVENESS FOR THE 1980-1990 TIME FRAME FOR ELECTRO-OPTICAL SYSTEMS.

3. MICROWAVE DEVICES

3.1 CIRCLE ON THE LIST PROVIDED TECHNOLOGICAL AREAS WHICH ARE TO BE UTILIZED IN THE SUBJECT WEAPON SYSTEM.

MICROWAVE DEVICES

a. TUBES
   1. Millimeter Wave Tubes (TWT)
   2. Gyrotron oscillator and amplifier
   3. Cathode-field emmiter and thermionic materials
   4. Klystrons
   5. Electron beam semiconductor (EBS)
   6. Thyratron
   7. Magnetrons
   8. High-Shock Quartz-Crystal Resonators

b. SOLID STATE
   1. TED-transferred-electron devices
   2. FET-field-effect transistors
   3. Bipolar
   4. Power combining
   5. Materials

c. OTHER
   1. SAWs- Surface Acoustic Waves
   2. Josephson junctions
   3. Monolithic ICs

3.1.1 WHAT OTHER TYPES OF MICROWAVE TECHNOLOGY WILL BE USED ON THE WEAPON SYSTEM WHICH IS NOT IN THE PROVIDED LIST?

3.2 HOW IS THE PERTINENT TECHNOLOGY UTILIZED IN THE WEAPON SYSTEM?

3.3 IS CURRENT ARMY TEST EQUIPMENT ADEQUATE TO SUPPORT THIS NEW TECHNOLOGY?

3.3.1 IF IT IS, HOW IS IT BEING SUPPORTED?

3.3.2 IF NOT, CAN CURRENT ARMY TEST EQUIPMENT BE ADAPTED TO SUPPORT THIS NEW TECHNOLOGY? EXPLAIN

3.3.3 IF IT IS NOT ADAPTABLE, WHAT PLANS EXIST TO SUPPORT THIS NEW TECHNOLOGY?

3.4 IN TESTING MICROWAVE DEVICES THE LACK OF SIGNAL GENERATORS OR SYNTHESIZERS AT THE REQUIRED FREQUENCIES MAY CAUSE A PROBLEM.

3.4.1 DOES YOUR EXPERIENCE INDICATE THAT THIS IS A MAJOR AREA OF CONCERN? ______________________________

3.4.2 WHAT OTHER AREAS ARE OF EQUAL OR GREATER CONCERN?

3.4.3 WHAT TMDE RESEARCH AND/OR DEVELOPMENT IF ANY WOULD YOU RECOMMEND? ______________________________

3.5 IN DEALING WITH MICROWAVE COMPONENTS THE NEED EXISTS FOR CALIBRATED OR CALIBRATABLE COMPONENTS, SUCH AS:

a. detectors

b. attenuators

c. couplers

d. switches

3.5.1 WHAT CURRENT ARMY TEST EQUIPMENT EXIST TO MEET THIS NEED? ______________________________

____

____

____

3.5.2 IS AUTOMATIC TEST EQUIPMENT APPLICABLE? __________

____

____

3.6 PLEASE LIST ANY AREAS IN WHICH YOU FEEL RESEARCH AND/OR DEVELOPMENT EFFORT IS NEEDED TO IMPROVE DS/GS TMDE EFFECTIVENESS FOR THE 1980-1990 TIME FRAME FOR MICROWAVE DEVICES. ______________________________

____

____

____

____

____

4. VERY LARGE SCALE INTEGRATED CIRCUITS

4.1 CIRCLE ON THE LIST PROVIDED TECHNOLOGICAL AREAS WHICH ARE TO BE UTILIZED IN THE SUBJECT WEAPON SYSTEM.

VLSI/VHSIC

a. ICs for logic
b. Memory
c. Signal Processing
d. Microprocessors
e. CCDs
f. MNOs
g. Magnetic Bubble
h. Microfabrication/Processing Technology
i. Radiation Hardening
j. CAD

4.1.1 WHAT OTHER TYPES OF VLSI/VHSIC TECHNOLOGY WILL BE USED ON THE WEAPON SYSTEM WHICH IS NOT IN THE PROVIDED LIST? ____________________

____

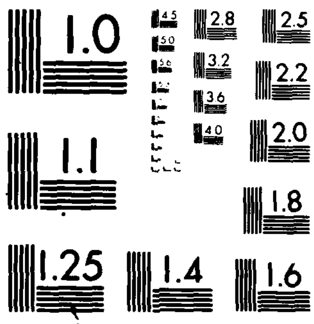
____

____

____

AD-A098 125 MANTECH INTERNATIONAL CORP ARLINGTON VA F/G 15/3
TECHNOLOGY SURVEY OF ADVANCED ARMY WEAPON SYSTEMS AND THEIR SUP--ETC(U)
MAR 81 J J RESSA, M COHILL N00024-79-C-7045
UNCLASSIFIED CORADCOM-79-7045-F NL

END
DATE
FILMED
5-81
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

4.2 HOW IS THE PERTINENT TECHNOLOGY UTILIZED IN THE WEAPON SYSTEM?

4.3. IS CURRENT ARMY TEST EQUIPMENT ADEQUATE TO SUPPORT THIS NEW TECHNOLOGY?

4.3.1 IF IT IS, HOW IS IT BEING SUPPORTED?

4.3.2 IF NOT, CAN CURRENT ARMY TEST EQUIPMENT BE ADAPTED TO SUPPORT THIS NEW TECHNOLOGY? EXPLAIN

4.3.3 IF IT IS NOT ADAPTABLE, WHAT PLANS EXIST TO SUPPORT THIS NEW TECHNOLOGY?

4.4 IN DEALING WITH THE TESTING OF VLSI THE MAJOR CONCERN IS TESTER SPEED. WHAT ARE YOUR REQUIREMENTS FOR THE VLSI WHICH NEED TO BE TESTED IN THE WEAPON SYSTEM? ______________________

____

____

____

____

4.5 DEVELOPMENT OF TEST PROGRAMS IS ANOTHER CONCERN WITH TESTING OF VLSI. WHICH OF THE CURRENT AUTOMATIC TEST PROGRAM GENERATION (ATPG) SYSTEMS (D4-Lasar, etc.) ARE BEING USED AT YOUR SITE? ____

____

____

____

____

4.5.1 WHAT IMPROVEMENTS ARE NEEDED WITH THE ATPG? ___________

____

____

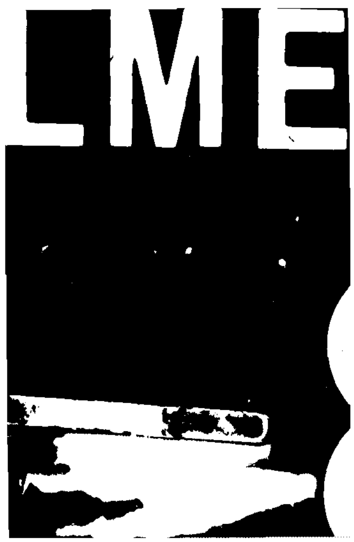
____

4.5.2 HOW COST EFFECTIVE IS ATPG OVER MANUAL PROGRAM GENERATION? ______________________________________

____

____

4.6 PLEASE LIST ANY AREAS IN WHICH YOU FEEL RESEARCH AND/OR DEVELOPMENT EFFORT IS NEEDED TO IMPROVE DS/GS TMDE EFFECTIVENESS FOR THE 1980-1990 TIME FRAME FOR VLSI OR VHSIC TECHNOLOGY.


LME